

FINAL

**Confirmation Sampling and Analysis Report
for Facility 1748, SWMU 134**



**Cape Canaveral Air Station
Florida**

Prepared For

**Air Force Center for Environmental Excellence
Brooks Air Force Base,
Texas**

and

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**45 CES/CEV
Patrick Air Force Base,
Florida**

March 1999

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**CONFIRMATION SAMPLING AND ANALYSIS REPORT
FOR
FACILITY 1748, SOLID WASTE MANAGEMENT UNIT 134
CAPE CANAVERAL AIR STATION, FLORIDA**

Prepared for:

**Air Force Center for Environmental Excellence
Brooks AFB, Texas**

and

**45 CES/CEV
Patrick AFB, Florida**

Contract F41624-92-8036, Delivery Order 17

March 1999

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ACRONYMS AND ABBREVIATIONS

45 CES/CEV	45 th Civil Engineering Squadron/Environmental Flight
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
AS	Air Station
AST	Aboveground storage tank
bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, xylenes
°C	Degrees Celsius
DO	Dissolved oxygen
ES	Engineering-Science, Inc.
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
HVW	Horizontal vent well
LNAPL	Light non-aqueous-phase liquid
µg/kg	Microgram(s) per kilogram
µg/L	Microgram(s) per liter
mg/kg	Milligram(s) per kilogram
mg/L	Milligram(s) per liter
MNA	Monitored natural attenuation
MP	Monitoring point
MTBE	Methyl-tertiary-butyl ether
mV	Millivolt(s)
NFA	No further action
PAH	Polynuclear aromatic hydrocarbon
Parsons ES	Parsons Engineering Science, Inc.
PID	Photoionization detector
POC	Point of compliance
QA	Quality assurance
QC	Quality control
RCRA	Resource Conservation and Recovery Act
Redox	Reduction/oxidation
RFI/CMS	RCRA Facility Investigations/Corrective Measures Study
RSKSOP	Robert S. Kerr Standard Operating Procedure
SAI	Specialized Assays, Inc.
SAP	Sampling and analysis plan
SQL	Sample quantitation limit
SWMU	Solid waste management unit
TCL	Target cleanup level
TRPH	Total recoverable petroleum hydrocarbons
TVH	Total volatile hydrocarbons

FINAL

USEPA
UST
VOC
VW

US Environmental Protection Agency
Underground storage tank
Volatile organic compound
Vent well

SECTION 1

INTRODUCTION

1.1 PURPOSE

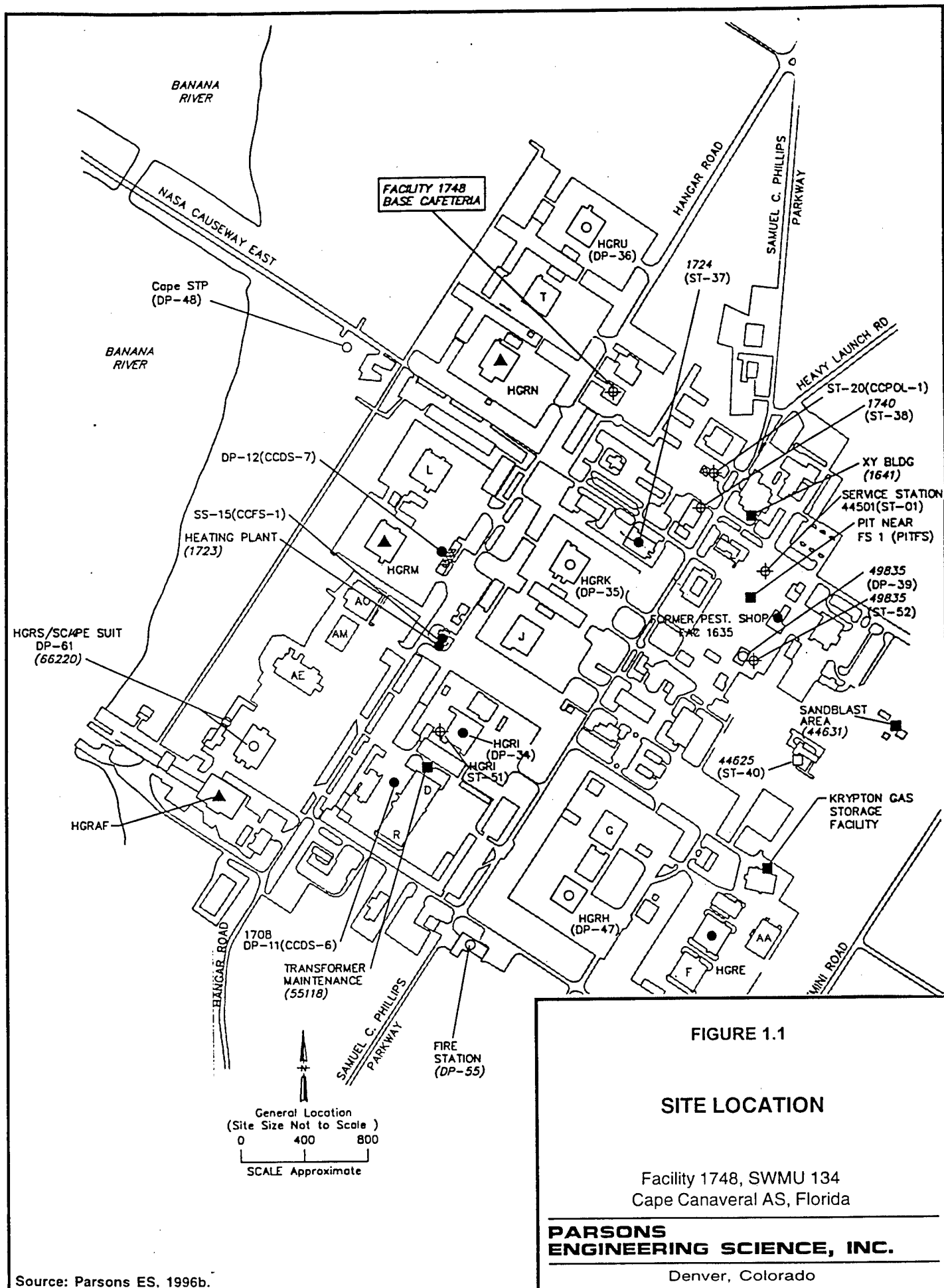
This confirmation sampling and analysis report for Facility 1748, Solid Waste Management Unit (SWMU) 134, at Cape Canaveral Air Station (AS), Florida, has been prepared by Parsons Engineering Science, Inc. (Parsons ES, formerly Engineering-Science, Inc. [ES]) for submittal to the Florida Department of Environmental Protection (FDEP); the US Air Force Center for Environmental Excellence (AFCEE), Brooks Air Force Base (AFB), Texas, and the 45th Civil Engineering Squadron, Environmental Flight (45 CES/CEV), Patrick AFB, Florida. This report has been prepared as part of the AFCEE Extended Bioventing Project, under Contract F41624-92-8036, Delivery Order 17. The purpose of this report is to provide the results of the confirmation soil and groundwater sampling performed at the site in July 1998, which document the effectiveness of soil remediation to date, and compare soil and groundwater analytical results with FDEP (1997) target cleanup levels (TCLs).

1.2 SITE AND PROJECT BACKGROUND

1.2.1 Site Description and Background

Cape Canaveral AS is located on the barrier island system situated off Florida's east coast, in Brevard County. The AS is bounded on the east by the Atlantic Ocean and on the west by the Banana River. Facility 1748, a Base cafeteria, is located on Hangar Road within the industrial portion of Cape Canaveral AS (Figure 1.1). A layout of the Facility 1748 site, including the soil remediation system components, is provided on Figure 1.2. Off the southern corner of Facility 1748, a 4,000-gallon underground storage tank (UST) was installed during facility construction in 1958. This UST was used to store diesel fuel for the cafeteria boilers until March 1992, and was replaced with a 5,000-gallon aboveground storage tank (AST) in May 1992. The UST and the associated piping were removed in December 1993.

Vadose zone soils at Facility 1748 consist of fine- to medium-grained sand from the surface to a depth of approximately 4.5 feet below ground surface (bgs). At depths greater than 4.5 feet bgs, soils in the vadose zone and within the surficial aquifer consist of fine- to coarse-grained quartz sand with shell fragments.



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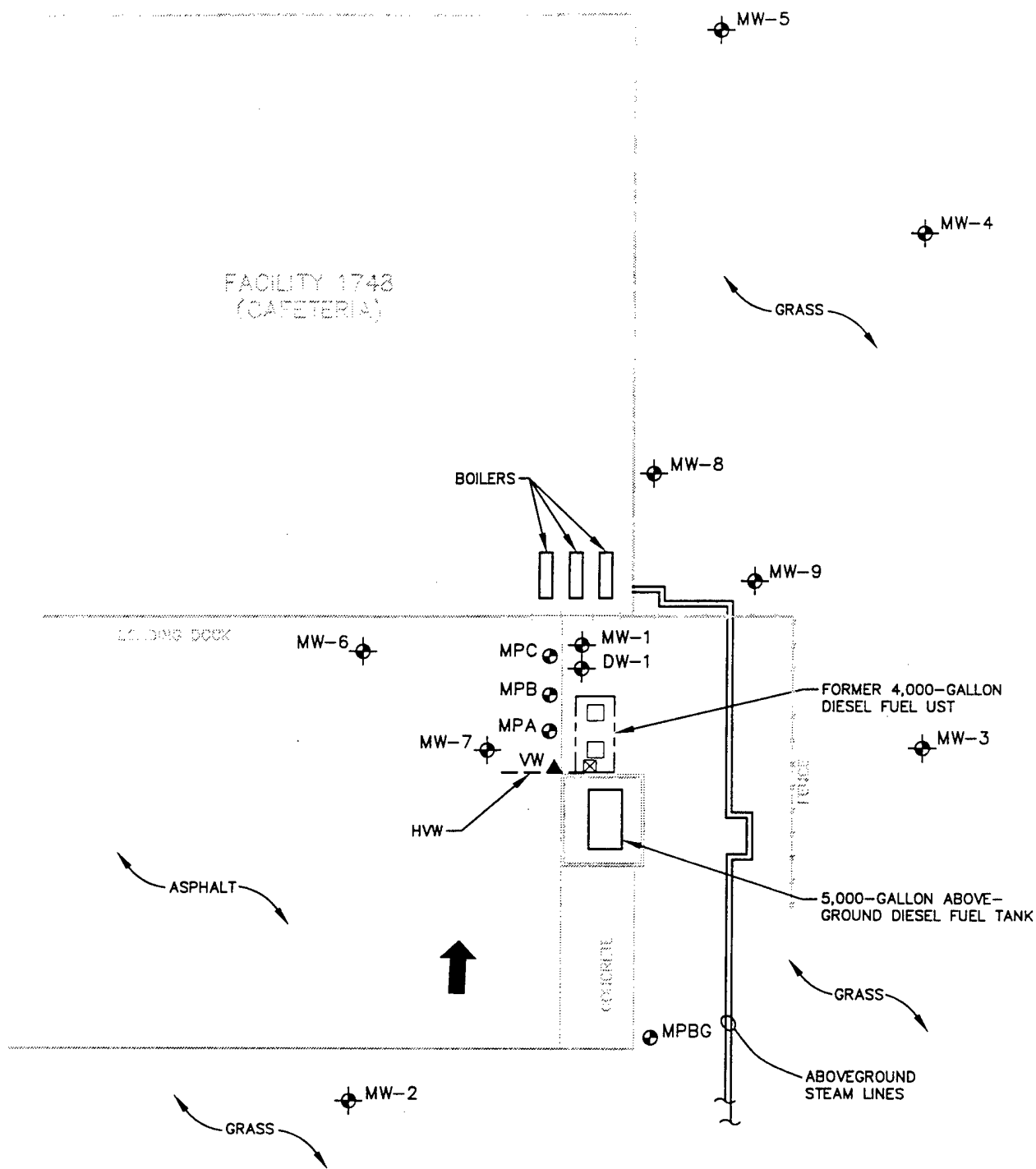


FIGURE 1.2

SITE LAYOUT

Facility 1748, SWMU 134
Cape Canaveral AS, Florida

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Two primary aquifers are present within this area, an unconfined surficial aquifer and the confined Floridian Aquifer. At Facility 1748, the surficial aquifer is encountered at depths that fluctuate between 2.5 and 8 feet bgs. Groundwater flow in the shallow aquifer at Facility 1748 is generally to the north-northeast (CH2M Hill, 1994 and 1995). At Cape Canaveral AS, neither the surficial aquifer nor the Floridian Aquifer are used for potable water supply. The Station receives its potable water from the City of Cocoa from a source in east Orange County (Parsons ES, 1996b).

Previous site investigations identified petroleum hydrocarbon contamination associated with the former diesel fuel UST at Facility 1748 in site soils and groundwater. These investigations included contaminant assessments conducted by CH2M Hill (1994 and 1995), and bioventing pilot testing and monitoring (ES, 1994; Parsons ES, 1996a, 1996b, and 1996c). Identified fuel-related contaminants included benzene, toluene, ethylbenzene, xylenes (BTEX), total recoverable petroleum hydrocarbons (TRPH), and polynuclear aromatic hydrocarbons (PAHs). Nine shallow monitoring wells (MW-1 through MW-9) and one deep monitoring well (DW-1) were installed during contamination assessment activities to evaluate petroleum hydrocarbon contamination in the surficial aquifer. Shallow monitoring wells MW-1 through MW-6 were screened from 2 to 12 feet bgs and wells MW-7 through MW-9 were screened from 3.6 to 13.6 feet bgs in order to characterize and monitor dissolved hydrocarbon contamination and the presence of light non-aqueous phase liquids (LNAPLs) near the water table surface. DW-1 was installed in the source area, adjacent to MW-1, and screened from 25 to 35 feet bgs. DW-1 represents an "intermediate zone" monitoring well within the surficial aquifer and was installed to evaluate the vertical extent of contamination at this location (Figure 1.2).

The approximate extent of petroleum hydrocarbon contamination in unsaturated and saturated soils prior to remediation activities is illustrated on Figure 1.3. Results from previous investigations have shown that petroleum hydrocarbon contamination in groundwater primarily has been limited to the shallow source area monitoring well (MW-1). Measurable free-phase product (mobile LNAPL) was observed in MW-1 in August 1993 and April 1995, but was not detected during subsequent sampling. Chlorinated volatile organic compound (VOC) contamination also has been observed in groundwater samples from DW-1. This contamination has been attributed to a large solvent plume originating in the Hangar K area (Site DP-35), approximately 1,200 feet south of (upgradient from) Facility 1748 (Figure 1.1). The Hangar K plume is the focus of a separate effort (the Resource Conservation and Recovery Act [RCRA] Facility Investigation and Corrective Measures Study [RFI/CMS]). More complete summaries of previous site investigations are included in the sampling and analysis plan (SAP), provided in Appendix A.

1.2.2 Project Background

In 1993, Facility 1748 was selected as a pilot-test site for the AFCEE Bioventing Initiative Program (Contract F33615-90-D-4014, Delivery Order 14). This program included conducting more than 135 *in situ* pilot tests at 48 military installations nationwide. These tests were designed to collect data on the effectiveness of bioventing

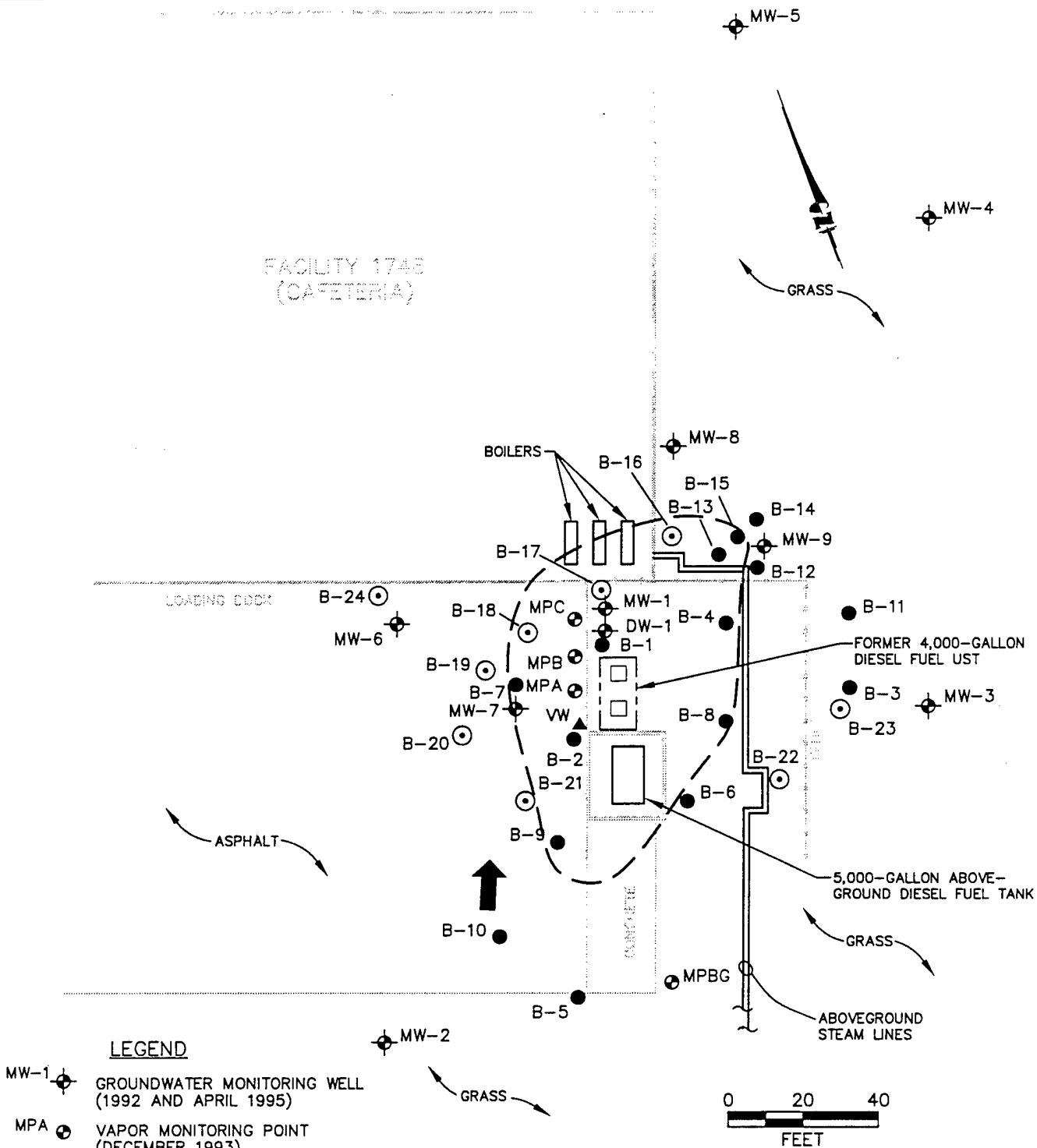


FIGURE 1.3

ESTIMATED EXTENT OF SOIL CONTAMINATION PRIOR TO BIOVENTING

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Cape Canaveral AS, Florida

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for the remediation of soil contaminated with fuel hydrocarbons (e.g., JP-4 jet fuel, diesel fuel, gasoline, heating oil, and other fuels and petroleum-based solvents).

Prior to pilot testing, a soil gas survey was conducted at Facility 1748 in July 1993 to determine the extent of oxygen depletion in vadose zone soils near the UST (ES, 1994). Based on this survey, it appeared that aerobic biodegradation of petroleum hydrocarbon contaminants in soils was occurring and would likely be enhanced by supplying supplemental oxygen to the subsurface (i.e., air injection bioventing). Following removal of the UST in December 1993, a bioventing system was installed at Facility 1748 to remediate the hydrocarbon contamination identified in vadose zone soils. The system consisted of one vertical air injection vent well (VW) screened from 3 to 8 feet bgs, four soil gas monitoring points (MPs) including one background monitoring point (MPA, MPB, MPC, and MPBG), each installed at 5.5 feet bgs, and a 1-horsepower regenerative blower (Figure 1.2). Initial soil and soil gas samples were collected and analyzed; initial *in situ* respiration tests were performed, and fuel biodegradation rates were calculated; and an air permeability test was performed. Results of the initial pilot test demonstrated that bioventing was an effective technology for remediation of site soils (ES, 1994).

Following initial testing, operation of the pilot-scale air-injection bioventing system was continued as part of the Bioventing Initiative Program and AFCEE Extended Bioventing Project (F41624-92-D-8036, Delivery Order 17). Elevated water table conditions prevented 1-year testing, and as a result the bioventing system was operated continuously for 18 months before being shutdown in December 1995 for soil and soil gas sampling and *in situ* respiration testing. Elevated water table conditions again prevented soil gas sampling and respiration testing at the MPs. Testing results at the VW indicated that total volatile hydrocarbons (TVH) and BTEX had been significantly reduced as a result of 18 months of bioventing air injection; however, the respiration rate at this location was only slightly reduced relative to pre-bioventing respiration rates. Minimal BTEX were observed in the 18-month soil samples, but reductions in TRPH were less notable (Parsons ES, 1996a).

Following 18-month testing, the bioventing system was restarted and operated until April 1996. After a 1-month blower shutdown period, soil gas samples were collected and analyzed, and respiration tests were conducted in May 1996. Soil gas sampling and respiration testing were performed at newly installed 3-foot monitoring points at MPA, MPB, and MPC, because elevated water table conditions continued to prevent testing at the 5.5-foot screened intervals. While soil gas sampling results indicated that little TVH contamination remained in site soils following approximately 2 years of air injection bioventing, static oxygen measurements indicated anaerobic soil conditions, and respiration testing results indicated that respiration and fuel biodegradation rates were only slightly reduced compared to pre-bioventing values. Based on these results, confirmation soil sampling as funded under the AFCEE Extended Bioventing project appeared to be premature, and continued system operation was recommended (Parsons ES, 1996c).

The pilot-scale bioventing system was operated for approximately 23 additional months prior to performance of confirmation soil sampling activities in July 1998. In November 1996, the vertical VW that had been installed during the initial pilot test was replaced with a horizontal vent well (HVW) to ensure oxygenation of vadose zone soils year-round, even during periods of elevated water table conditions. As of July 1998, the pilot-scale bioventing system had been operating for approximately 4 years; however, only 1.5 years of this treatment period included HVW air injection.

This report presents the results of confirmation soil and groundwater sampling performed by Parsons ES in July 1998 at Facility 1748. In preparation for the confirmation sampling event, a site-specific SAP was prepared by Parsons ES (1998). A copy of the SAP is provided as Appendix A. Following FDEP, AFCEE, and Patrick AFB approval of the SAP, confirmation sampling was conducted at Facility 1748 on 29 and 30 July 1998. Confirmation soil sampling activities consisted of advancing nine boreholes to within 1 foot of the groundwater surface (encountered at approximately 6.5 to 7 feet bgs), and analyzing selected soil samples collected from the top of the capillary fringe for fuel hydrocarbon constituents. Confirmation groundwater sampling activities consisted of collecting groundwater samples from six monitoring wells for fixed-based laboratory analysis of hydrocarbon constituents and select geochemical parameters. In addition, groundwater samples from these wells were analyzed onsite for additional geochemical parameters to evaluate the potential for biodegradation (i.e., natural attenuation) of dissolved petroleum hydrocarbons.

1.3 SUMMARY OF CONFIRMATION SAMPLING RESULTS

Results of the soil analyses indicate that remediation activities at the site have reduced ethylbenzene and total xylenes concentrations in soil by 1 order of magnitude and TRPH have been reduced between 40 and 60 percent. However, total xylenes, benzo(a)anthracene, benzo(a)pyrene, and TRPH remain in site soils at concentrations exceeding FDEP (1997) soil leachability TCLs (see Section 3). Groundwater analyses confirm that petroleum hydrocarbon contaminants are leaching to groundwater in the original source area, near the former diesel fuel UST. Benzene, ethylbenzene, benzo(a)anthracene, benzo(a)pyrene, and TRPH were detected in groundwater at monitoring well MW-1 at concentrations exceeding FDEP (1997) no-further-action (NFA) TCLs. Although petroleum hydrocarbon concentrations in groundwater have decreased significantly since October 1992, and were below FDEP (1997) default values for consideration of monitored natural attenuation (MNA) as a remedial alternative, rate-of-contaminant-loss calculations for TRPH indicate that it may take more than 10 years for TRPH levels to reach the NFA TCL of 5 milligrams per liter (mg/L) for groundwater. While natural attenuation is helping to reduce petroleum hydrocarbon concentrations in groundwater, an MNA-only proposal, in accordance with FDEP (1997) criteria, is not currently valid because TRPH levels in source area groundwater are not expected to meet NFA requirements within 5 years.

Based on these results, and the May 1996 soil gas sampling and respiration testing results, it appears that further fuel hydrocarbon reductions in soil are warranted, and continued bioventing system operation at Facility 1748 is recommended. If future

monitoring results indicate that bioventing is not effectively reducing the loading of petroleum hydrocarbon contaminants to groundwater, excavation of source area soils or establishment of alternative TCLs should be considered.

1.4 REPORT ORGANIZATION

This confirmation sampling and analysis report consists of five sections, including this introduction, and five appendices. Section 2 includes a description of the confirmation soil and groundwater sampling performed at the site in July 1998. Section 3 summarizes soil and groundwater analytical results, compares the results against FDEP (1997) TLCs, and provides an evaluation of the natural attenuation potential for dissolved-phase fuel hydrocarbons. Section 4 presents conclusions and recommendations; references used in the preparation of this report are provided in Section 5.

Appendix A presents a copy of the confirmation SAP for Facility 1748, which includes a detailed summary of previous site investigations and bioventing pilot testing and extended operation activities. Appendix B presents the field notes that were taken during the July 1998 confirmation soil and groundwater sampling effort. Appendix C presents laboratory analytical data for site environmental and quality assurance/quality control (QA/QC) samples, and chain-of-custody forms, and Appendix D presents the Parsons ES data quality assessment report. Appendix E presents contaminant-loss calculations for site groundwater.

SECTION 2

CONFIRMATION SAMPLING AND ANALYSIS ACTIVITIES

This section summarizes confirmatory soil and groundwater sampling activities, including sampling locations and sampling depths, sampling procedures, analytical methods, equipment decontamination procedures, and QA/QC procedures. These methods and procedures are described in more detail in the confirmation SAP for Facility 1748 (see Appendix A). The SAP was implemented by qualified Parsons ES scientists trained in conducting soil and groundwater sampling, records documentation, and chain-of-custody procedures. Laboratory sample analyses were performed by Specialized Assays, Inc. (SAI) of Nashville, Tennessee, a State of Florida-certified analytical laboratory.

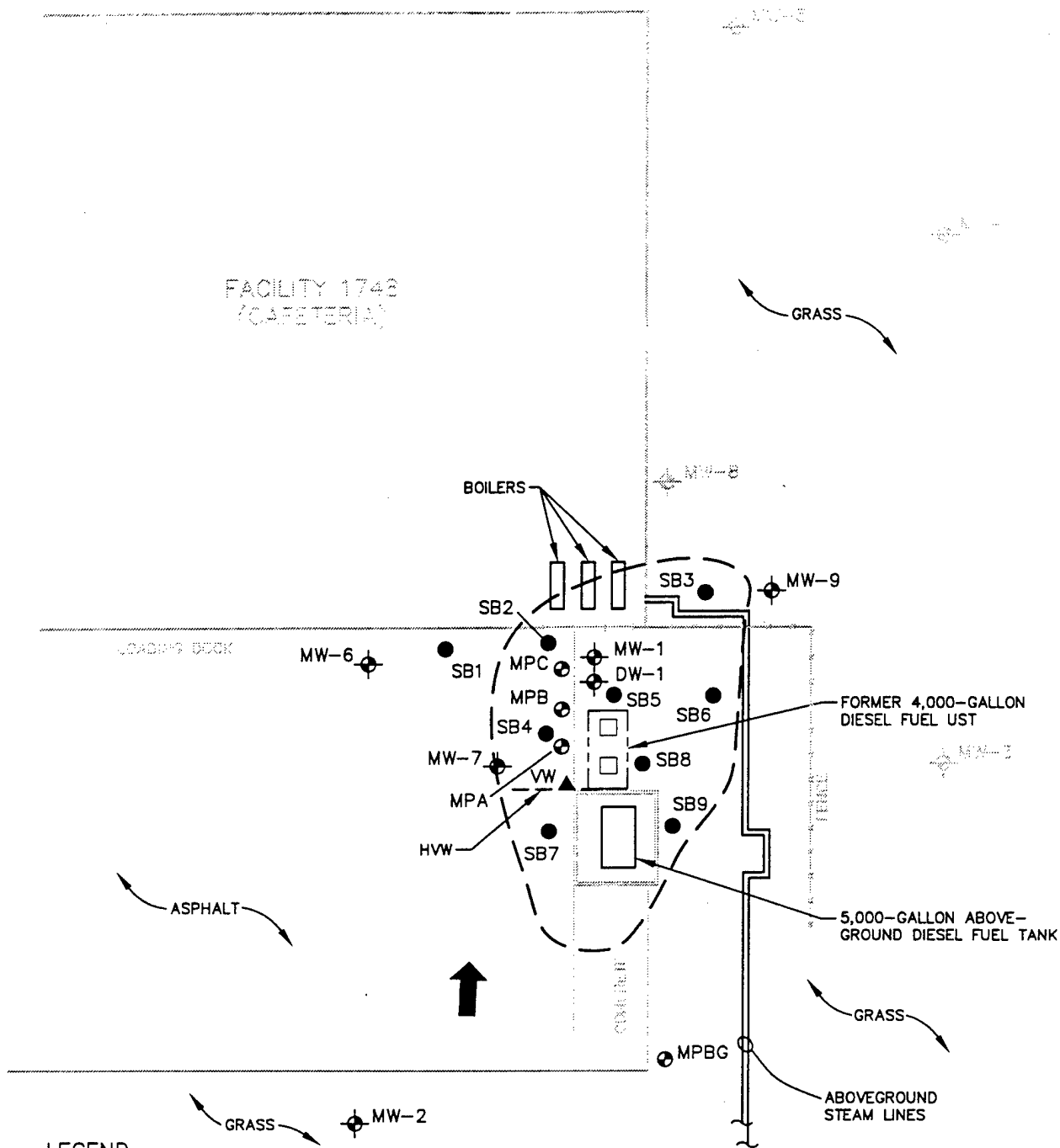
2.1 SOIL SAMPLING PROCEDURES

2.1.1 Borehole Locations and Sampling Depths

Confirmatory soil sampling was conducted at Facility 1748 on 30 July 1998. Nine boreholes (SB1 through SB9) were advanced at the site, and 10 soil samples (one primary sample from each of SB1 through SB9, and one replicate sample collected at SB4) were collected for laboratory analysis. The boreholes were located in the vicinity of the former diesel fuel UST and in the area previously shown to contain petroleum hydrocarbon soil contamination. Figure 2.1 shows the locations of the nine confirmatory soil boreholes. Each soil borehole was advanced to slightly deeper than 6 feet bgs with a hand auger. Soil samples were collected at each location at depths between 5.7 and 6.2 feet bgs. Groundwater was encountered at depths of approximately 6.5 to 7 feet bgs during the July 1998 sampling event.

2.1.2 Soil Sampling and Analysis

Undisturbed soil samples, suitable for chemical analysis, were obtained from each borehole by collecting the required volume of soil directly from the hand-auger bucket. Soil types were described in accordance with the standard Parsons ES soil description format. All soil samples were visually examined, and sample headspaces were field screened for VOCs using a Photovac Microtip® photoionization detector (PID). The data obtained from the examination and screening were recorded in the field notes (Appendix B).



- LEGEND**
- MW-1 GROUNDWATER MONITORING WELL SAMPLED
 - SB1 CONFIRMATION SOIL BOREHOLE
 - MPA VAPOR MONITORING POINT
 - VW VERTICAL AIR INJECTION VENT WELL
 - HVW HORIZONTAL AIR INJECTION VENT WELL
 - 1992 ESTIMATED EXTENT OF TOTAL VOLATILE HYDROCARBON CONTAMINATION EXCEEDING 100 ppmv IN SATURATED AND UNSATURATED SOIL HEADSPACE MEASUREMENTS
 - GROUNDWATER FLOW DIRECTION

FIGURE 2.1

**CONFIRMATION SOIL
AND GROUNDWATER
SAMPLING LOCATIONS**

Facility 1748, SWMU 134
Cape Canaveral AS, Florida

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Based on field headspace screening results, one sample with the greatest apparent petroleum hydrocarbon contamination from each boring (SB1 through SB9) was selected and submitted for laboratory analysis using laboratory-prepared containers. A replicate soil sample also was collected from soil borehole SB4 and submitted for laboratory analysis. Samples selected for laboratory analysis were labeled with the site name and borehole number, sample depth, date of collection, requested analyses, project name, and other pertinent data. The sample containers were sealed in plastic bags and immediately placed in an insulated cooler containing ice. The soil samples were maintained in a chilled condition until delivered to the analytical laboratory. Chain-of-custody records were prepared in the field and accompanied the samples to SAI.

A total of 10 confirmatory soil samples (one sample from a mean depth of 6 feet bgs from SB1 through SB9, and one replicate sample from 6 feet bgs at SB4) were collected at the site and submitted for laboratory analysis of BTEX and other VOCs by US Environmental Protection Agency (USEPA) Method SW8021B, PAHs using USEPA Method SW8310, and TRPH using State of Florida Method FLA PRO. A trip blank and an equipment rinseate blank were also submitted for laboratory analysis of BTEX and other VOCs by USEPA Method SW8021B. All samples were analyzed by SAI, a State of Florida-certified analytical laboratory. Analytical results are presented in Section 3.

2.1.3 Equipment Decontamination

Augers and other sampling equipment were cleaned before use and between boreholes to prevent cross-contamination. Between sampling events, the hand-auger bucket was cleaned with Alconox[®] detergent, followed by successive potable and distilled water rinses.

2.1.4 Borehole Backfilling Procedures

Auger cuttings were returned to the borehole from which they were generated. Boreholes drilled through asphalt were repaired at the surface using asphalt cold-patch.

2.2 GROUNDWATER SAMPLING PROCEDURES

Groundwater samples were collected at Facility 1748 on 29 and 30 July 1998 from six existing groundwater monitoring wells (MW-1, DW-1, MW-2, MW-6, MW-7, and MW-9) to determine the magnitude and extent of dissolved fuel constituents and to determine any changes that had occurred since previous groundwater sampling events. The groundwater sampling locations are shown on Figure 2.1. Samples from these six wells also were analyzed in the field for electron acceptors and other geochemical parameters to assess the potential for remediation of dissolved-phase hydrocarbons by natural attenuation. Samples from a source area well (MW-1) and a well upgradient from the former UST location (MW-2), were collected for laboratory methane analysis. Groundwater sampling was performed in accordance with the procedures outlined in the SAP (Appendix A), with one exception. The SAP specified that a groundwater sample

would be collected from well MW-8. However, MW-8 could not be located, and MW-7 was used as a replacement sampling location.

2.2.1 Well Purging

Prior to removing any water from the well, the static water level was measured. A decontaminated water level probe was used to measure the depth to groundwater below the well datum (to the nearest 0.01 foot). After measuring the static water level, the water level probe was lowered slowly to the bottom of the well, and the total well depth was measured to the nearest 0.01 foot. Based on these measurements, the volume of water in the well casing was calculated, and a minimum of three times the calculated volume was removed from the well. A peristaltic pump with dedicated, disposable tubing was used to purge groundwater from each well prior to sampling. The pH, temperature, specific conductivity, and reduction/oxidation (redox) potential were monitored before, during, and after well purging and recorded in the field notes (Appendix B). Following removal of at least three casing-volumes of water, well purging was continued until the pH, temperature, specific conductivity, and redox potential stabilized to within 10 percent of previous readings. Purge water was discharged onto the ground surface adjacent to the well from which it was removed.

2.2.2 Sample Extraction, Handling, and Analysis

A peristaltic pump with dedicated, disposable tubing was used to extract groundwater samples from each well. The extraction equipment was lowered into the water gently to prevent splashing, and well water was extracted slowly to minimize volatilization of contaminants. Samples were transferred directly into analyte-appropriate sample containers provided by SAI. The water was carefully poured down the inner walls of the sample bottle to minimize aeration of the sample. Sample containers were filled so that air was eliminated, and the container lids were tightly closed. The sample bottles were labeled with the site name and well number, sample depth, date of collection, project name, and other pertinent data. Samples were properly prepared for transport to SAI by placing the samples in a cooler containing ice to maintain a shipping temperature of approximately 4 degrees Celsius (°C). Chain-of-custody records were prepared in the field and accompanied the samples to SAI.

Seven groundwater samples for laboratory analysis (including one replicate sample) were collected at the six wells. All groundwater samples were sent to SAI. All samples were analyzed for BTEX and other VOCs by SW8021B, PAHs using USEPA Method SW8310, TRPH using State of Florida Method FLA PRO, and sulfate using USEPA Method SW9056. In addition, two samples were analyzed for methane using USEPA Method SW8015M. One replicate groundwater sample (17 percent), one equipment blank, and one trip blank also were submitted for laboratory analysis of BTEX and other VOCs by USEPA Method SW8021B. Analytical results are presented in Section 3.

2.2.3 Onsite Chemical Parameter Measurement

Many of the groundwater chemical parameters listed in Table 4.2 of the SAP (Appendix A) were measured onsite by Parsons ES personnel. Temperature, pH, specific conductivity, redox potential, dissolved oxygen (DO), and turbidity measurements were made using direct-reading meters, while other parameters were measured using a Hach® portable colorimeter in accordance with specific Hach® analytical procedures. These procedures are described in Section 4 of the SAP (Appendix A). Results of the field analyses are summarized in Section 3.

2.2.4 Equipment Decontamination

Because new, disposable tubing was used for well purging and sample extraction, the water-level probe and cable were the only sampling equipment contacting the samples, and therefore the only equipment requiring decontamination. The decontamination procedures that were followed are described in the SAP (Appendix A).

2.3 FIELD AND LABORATORY DATA QUALITY ASSURANCE/QUALITY CONTROL

Samples were collected, preserved, transported, and analyzed in such a manner that the sampling results would provide a reliable representation of the soil and groundwater quality at the site. To meet this requirement, the procedures described in Section 4 of the SAP (Appendix A) were followed during sample collection, handling, and analysis. One field soil replicate and one groundwater replicate were collected as QA samples. An equipment rinseate and a trip blank were also submitted to SAI. In addition, laboratory QC samples were prepared and analyzed.

Parsons ES performed a Level III validation of the Facility 1748 soil and groundwater data. Results of the assessment indicated that no data should be rejected based on validation, and all data are usable for the purposes intended. A copy of the data quality assessment report has been provided as Appendix D.

SECTION 3

CONFIRMATION SAMPLING RESULTS

This section summarizes the analytical results from confirmation soil and groundwater sampling activities. Soil and groundwater cleanup criteria proposed in the SAP also are compared to analytical results. In addition, natural attenuation of petroleum hydrocarbon contaminants in site groundwater is evaluated.

3.1 LABORATORY SOIL RESULTS

Soil analytical results are summarized in Table 3.1, and data from SAI are provided in Appendix C. Ten soil samples from nine borehole locations were analyzed by SAI for VOCs by USEPA Method SW8021B, PAHs by USEPA Method SW8310, and TRPH using the State of Florida Method FLA PRO. All soil samples submitted for laboratory analysis were collected from the top of the capillary fringe at approximately 6 feet bgs.

The results of the SW8021B analyses for VOCs indicate the presence of ethylbenzene and xylenes in the majority of soil samples. Maximum concentrations of ethylbenzene (370 micrograms per kilogram [$\mu\text{g}/\text{kg}$]), *m*- and *p*-xylenes (490 $\mu\text{g}/\text{kg}$), and *o*-xylene (255 $\mu\text{g}/\text{kg}$) were detected at SB4, SB6, and SB3, respectively (Figure 2.1). Toluene was detected at a maximum estimated concentrations of 44.8 J $\mu\text{g}/\text{kg}$ in the SB4 replicate sample and at 18.9 $\mu\text{g}/\text{kg}$ at SB8. Benzene was detected in two samples, SB4 and its replicate sample, at estimated concentrations of 2.8 J $\mu\text{g}/\text{kg}$ and 1.3 $\mu\text{g}/\text{kg}$, respectively. 1,4-dichlorobenzene was detected at SB8 at 4 $\mu\text{g}/\text{kg}$, and methyl-tertiary-butyl-ether (MTBE) was detected at SB1 at an estimated concentration of 2.1 J $\mu\text{g}/\text{kg}$. There were no detections of chlorobenzene, 1,1-dichlorobenzene and 1,3-dichlorobenzene in any of the soil samples. No VOCs were detected in the soil sample from SB9.

The results of the SW8310 analyses indicated the presence of PAHs in all soil samples (Table 3.1). Benzo(a)anthracene was detected in all soil samples at concentrations ranging from 214 $\mu\text{g}/\text{kg}$ (SB9) to 3,000 $\mu\text{g}/\text{kg}$ (SB4). Benzo(a)pyrene was detected in four soil samples (SB3, SB5, SB8, and SB9) at estimated concentrations ranging from 95J $\mu\text{g}/\text{kg}$ to 1,400J $\mu\text{g}/\text{kg}$. Chrysene was detected in five soil samples (SB1, SB2, SB3, SB7, and SB8) at concentrations ranging from 964J $\mu\text{g}/\text{kg}$ to 5,580 $\mu\text{g}/\text{kg}$. Fluoranthene was detected in seven soil samples (SB2, SB4 through SB8, and the replicate soil sample at SB4) at estimated concentrations ranging from 2,260J $\mu\text{g}/\text{kg}$ to 9,270J $\mu\text{g}/\text{kg}$. Fluorene was detected in two soil samples (the replicate soil sample at SB4 and SB6) at estimated concentrations ranging from 1,400J $\mu\text{g}/\text{kg}$ to

TABLE 3.1
JULY 1998 SOIL ANALYTICAL RESULTS COMPARED TO TARGET CLEANUP LEVELS
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Analyte	Units	Sampling Location (Soil borehole - depth in feet below ground surface)											
		FDEP Target Cleanup Levels ^a		Replicate									
		I	II	SB1-6	SB2-6	SB3-6	SB4-6	SB4-6	SB5-6	SB6-6	SB7-6	SB8-6	SB9-6
Method SW8021													
1,2-Dichlorobenzene	µg/kg ^d	NA ^e	NA	4.2 UJ ^f	4.2 UJ	4.4 UJ	4.7 UJ	4.8 UJ	4.6 UJ	4.2 UJ	4.8 UJ	5.3 UJ	4.8 UJ ^g
1,3-Dichlorobenzene		NA	NA	4.2 UJ	4.2 UJ	4.4 UJ	4.7 UJ	4.8 UJ	4.6 UJ	4.2 UJ	4.8 UJ	5.3 UJ	4.8 UJ
1,4-Dichlorobenzene		NA	NA	3.1 UJ	3.1 UJ	3.3 UJ	3.5 UJ	3.6 UJ	3.4 UJ	3.2 UJ	3.6 UJ	4	3.6 UJ
Benzene		1,100	1,500	1.0 UJ	1.0 UJ	1.1 UJ	2.8 J ^h	1.3 J	1.1 UJ	1.1 UJ	1.2 UJ	1.3 UJ	1.2 UJ
Chlorobenzene		NA	NA	2.1 UJ	2.1 UJ	2.2 UJ	2.3 UJ	2.4 UJ	2.3 UJ	2.1 UJ	2.4 UJ	2.7 UJ	2.4 UJ
Ethylbenzene		240,000	240,000	140	170	162 J	370	265	105	295	12.2 J	46.8	2.4 UJ
m,p-Xylenes		NA	NA	165	160	345	415	320	35.5 J	490	39.5 J	66.5	2.4 UJ
o-Xylene		NA	NA	25 J	29.5 J	255	180	160	26.8 J	105	26.0 J	22.7	2.4 UJ
Total Xylenes ^d		290,000	290,000	190	189.5	600	595	480	62.3 J	595	65.5 J	89.2	2.4 UJ
MTBE ^a		350,000	6,100,000	2.1 J	2.1 UJ	2.2 UJ	2.3 UJ	2.4 UJ	2.3 UJ	2.1 UJ	2.4 UJ	2.7 UJ	2.4 UJ
Toluene		300,000	2,000,000	12.1 J	15.7 J	7.0 J	62 J	44.8 J	9.3 J	14.4 J	2.3 J	18.9	2.4 UJ
Method SW8310													
Acenaphthylene	µg/kg	1,100,000	11,000,000	64,200 U	64,200 U	67,700 U	71,600 U	74,200 U	70,800 U	64,800 U	74,200 U	82,100 U	18,300 U
Acenaphthene		2,300,000	22,000,000	50,000 U	50,000 U	52,700 U	55,800 U	57,800 U	55,200 U	50,500 U	57,800 U	64,000 U	14,300 U
Anthracene		19,000,000	290,000,000	18,300 U	18,300 U	19,300 U	19,300 U	18,800 U	20,200 U	18,500 U	21,200 U	23,500 U	5,240 U
Benz(a)anthracene		1,400	5,100	764	611	1,480	3,000	2,200	1,200 J	702	980	1,710	214
Benz(a)pyrene		100	500	625 U	625 U	176 J	3,000 U	3,000 U	1,400 J	632 U	723 U	231 J	95 J
Benz(b)fluoranthene		1,400	5,000	500 U	500 U	527 U	2,400 U	2,400 U	2,400 U	505 U	578 U	640 U	143 U
Benz(g,h,i)perylene		2,300,000	45,000,000	2,080 U	2,080 U	2,200 U	10,000 U	10,000 U	10,000 U	2,110 U	24,10 U	2,670 U	595 U
Benz(k)fluoranthene		15,000	52,000	458 U	458 U	484 U	2,200 U	2,200 U	2,200 U	463 U	530 U	587 U	131 U
Chrysene		140,000	490,000	5,580	3,950 J	1,130 J	20,000 U	20,000 U	20,000 U	4,210 U	964 J	1,640 J	1,190 U
Dibenz(a,h)anthracene		100	500	833 U	833 U	879 U	4,000 U	4,000 U	4,000 U	842 U	964 U	1,070 U	238 U
Fluoranthene		2,800,000	45,000,000	5,830 U	2,260 J	6,150 U	9,270 J	7,470 J	6,270 J	3,650 J	2,890 J	4,730 J	1,670 U
Fluorene		2,100,000	24,000,000	5,830 U	5,830 U	6,150 U	6,510 U	2,110 J	6,440 U	1,400 J	6,750 U	7,470 U	1,670 U
Indeno(1,2,3-cd)pyrene		1,500	5,200	1,250 U	1,250 U	1,320 U	6,000 U	6,000 U	6,000 U	1,260 U	1,450 U	1,640 U	357 U
Naphthalene		1,000,000	8,600,000	50,000 U	50,000 U	52,700 U	55,800 U	57,800 U	55,200 U	50,500 U	57,800 U	64,000 U	14,300 U
Phenanthrene		1,900,000	29,000,000	17,500 U	17,500 U	18,500 U	84,000 U	84,000 U	19,300 U	17,700 U	20,200 U	22,400 U	5,000 U
Pyrene		2,200,000	40,000,000	1,570 J	7,500 U	7,910 U	36,000 U	36,000 U	36,000 U	7,580 U	8,670 U	9,600 U	2,140 U
Method FLA PRO													
TRPH ⁱ	mg/kg ^m	350	2,500	10,729	6,229	9,780	12,674	11,458	5,092	3,411	3,012	2,173J	444

Note: Shading denotes the target cleanup level (TCL) that was exceeded and the sample result that exceeds the TCL(s). Similarly, outlining denotes reporting limit exceeding TCL indicated.

^a FDEP, 1997

^b Direct Exposure I and II are for No Further Action Without Conditions and With Conditions, respectively

^c Based on Table V (Groundwater Target Cleanup Levels (FDEP, 1997))

^d µg/kg = micrograms per kilogram

^e NA = not available

^f UJ = not detected above the sample quantitation limit (SQL), however, the value shown is an estimate (see Appendix D)

^g U = not detected above the SQL shown (see Appendix D)

^h J = detected at the estimated concentration shown (see Appendix D)

ⁱ Sum of detected and/or estimated m,p xylenes and o-xylene concentrations.

^j ... = not applicable

^k MTBE = methyl tert-butyl ether

^l TRPH = total recoverable petroleum hydrocarbons

^m mg/kg = milligrams per kilogram

2,110J $\mu\text{g/kg}$. Pyrene was detected in one soil sample (SB1) at an estimated concentration of 1,570J $\mu\text{g/kg}$. No other PAHs were detected; however, due to matrix interference problems and dilution of samples during analysis, the sample quantitation limits (SQL) for some compounds were as high as 88,000 $\mu\text{g/kg}$.

Analysis of soil samples by State of Florida Method FLA PRO indicated elevated concentrations of TRPH in all 10 soil samples. TRPH concentrations ranged from 444 milligrams per kilogram (mg/kg) at SB9 to 12,674 mg/kg at SB4.

The effectiveness of the bioventing system at Facility 1748 can be evaluated by comparing soil BTEX and TRPH results from the confirmation sampling event to results from previous soil sampling efforts. During bioventing system installation, maximum detected concentrations of ethylbenzene at 5,100 $\mu\text{g/kg}$ and total xylenes at 8,300 $\mu\text{g/kg}$ were detected in soils 5.5 feet bgs at MPA (Appendix A, Table 2.4). In comparison, the primary and replicate samples from SB4, located near MPA (Figure 2.1), indicate that ethylbenzene and xylenes concentrations in soils at this location have been reduced by more than 1 order of magnitude. Average concentrations of TRPH in soil as measured during system installation and following 18 months of bioventing system treatment were 17,200 mg/kg and 15,200 mg/kg, respectively (Appendix A, Table 2.4). The average TRPH concentration in soil samples collected during the July 1998 confirmation sampling event was 6,500 mg/kg (Table 3.1). During bioventing system installation, the maximum detected concentration of TRPH was 20,200 mg/kg in soils 5.5 feet bgs at MPA. In comparison, the two confirmation soil samples collected near this location (6 feet bgs at SB4) (Figure 2.1) had an average TRPH concentration of 12,066 mg/kg. Relative to the BTEX compounds, TRPH reductions in site soils are less significant because the longer-chain, higher-molecular-weight petroleum hydrocarbons biodegrade more slowly.

3.2 LABORATORY GROUNDWATER RESULTS

Complete groundwater analytical results from SAI are presented in Appendix C, and the results are summarized in Table 3.2. Seven groundwater samples (including one replicate sample) were collected from six monitoring wells at the site (Figure 2.1), and submitted to SAI for analysis of VOCs by USEPA Method SW8021B, PAHs by USEPA Method SW8310, and TRPH using the State of Florida Method FLA PRO. Additionally, all samples were analyzed for sulfate by USEPA Method SW9056, and samples from wells MW-1 and MW-2 were analyzed for methane by Robert S. Kerr Standard Operating Procedure (RSKSOP) 175. No measurable free-phase LNAPL was detected in any of the wells sampled; however, a sheen was observed in water collected from MW-1.

Analysis of groundwater samples by SW8021B indicated VOCs were present only at the source area well (MW-1) (Table 3.2). Chlorinated benzenes and MTBE were not detected in any of the confirmation groundwater samples. In the MW-1 sample, benzene was detected at 7.3 micrograms per liter ($\mu\text{g/L}$), ethylbenzene was detected at 39.4 $\mu\text{g/L}$, and *m,p*-xylenes were detected at an estimated concentration of 1.1J $\mu\text{g/L}$. As shown on Table 2.3 of Appendix A, benzene, ethylbenzene, and total xylenes were

TABLE 3.2
JULY 1998 GROUNDWATER ANALYTICAL RESULTS COMPARED TO TARGET CLEANUP LEVELS
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Analyte	Units	FDEP Target Cleanup Levels ⁴		Sample Locations							
		Table V	Table IX	Source Wells			Perimeter Wells				
		NFA Cleanup Level ^b	Natural Attenuation Default Source ^c	Interval ^d	DW-1 25-35	DW-1-Rep ^e 25-35	MW-1 2-12	MW-2 2-12	MW-6 2-12	MW-7 3.6-13.6	MW-9 3.6-13.6
Method SW8021											
	µg/L ^f										
1,2-Dichlorobenzene		NA ^g	NA		4 U ^h	4 U	4 U	4 U	4 U	4 U	4 U
1,3-Dichlorobenzene		NA	NA		4 U	4 U	4 U	4 U	4 U	4 U	4 U
1,4-Dichlorobenzene		NA	NA		3 U	3 U	3 U	3 U	3 U	3 U	3 U
Benzene		1	100		2 U	2 U	7.3	2 U	2 U	2 U	2 U
Chlorobenzene		NA	NA		2 U	2 U	2 U	2 U	2 U	2 U	2 U
Ethylbenzene		30	300		2 U	2 U	39.4	2 U	2 U	2 U	2 U
m,p-Xylenes		NA	NA		2 U	2 U	1.1 J ⁱ	2 U	2 U	2 U	2 U
o-Xylene		NA	NA		2 U	2 U	2 U	2 U	2 U	2 U	2 U
Total Xylenes		20	200		---	---	---	---	---	---	---
MTBE ^k		35	350		2 U	2 U	2 U	2 U	2 U	2 U	2 U
Toluene		40	400		2 U	2 U	2 U	2 U	2 U	2 U	2 U
Method SW8310											
	µg/L										
Acenaphthylene		210	2,100		25.6 U	25.3 U	250 U	24.2 U	25 U	24.7 U	25 U
Acenaphthene		20	200		20 U	19.8 U	196 U	18.9 U	19.6 U	19.4 U	19.6 U
Anthracene		2,100	21,000		7.33 U	7.25 U	71.7 U	6.95 U	7.17 U	7.1 U	7.17 U
Benzo(a)anthracene		0.2	20		0.14 U	0.14 U	2.28	0.14 U	0.14 U	0.14 U	0.14 U
Benzo(a)pyrene		0.2	20		0.26 U	0.25 U	2.5	0.24 U	0.25 U	0.25 U	0.25 U
Benzo(b)fluoranthene		0.2	20		0.2 U	0.2 U	1.96 U	0.19 U	0.2 U	0.19 U	0.2 U
Benzo(g,h,i)perylene		210	2,100		0.84 U	0.84 U	8.26 U	0.8 U	0.83 U	0.82 U	0.83 U
Benzo(k)fluoranthene		0.5	50		0.19 U	0.19 U	1.85 U	0.18 U	0.18 U	0.18 U	0.18 U
Chrysene		5	500		1.67 U	1.65 U	16.3 U	1.58 U	1.63 U	1.61 U	1.63 U
Dibenzo(a,h)anthracene		0.2	20		0.33 U	0.33 U	3.26 U	0.32 U	0.33 U	0.32 U	0.33 U
Fluoranthene		280	2,800		2.33 U	2.31 U	22.8 U	2.21 U	2.28 U	2.26 U	2.28 U
Fluorene		280	2,800		2.33 U	2.31 U	5.22 J	2.21 U	2.28 U	2.26 U	2.28 U
Indeno(1,2,3-cd)pyrene		0.2	20		0.48 U	0.47 U	4.67 U	0.45 U	0.47 U	0.46 U	0.47 U
Naphthalene		20	200		20	19.8	196 U	18.9 U	19.6 U	19.4 U	19.6 U
Phenanthrene		210	2,100		7.11 U	7.03 U	69.6 U	6.74 U	6.96 U	6.88 U	6.96 U
Pyrene		210	2,100		3 U	2.97 U	29.3 U	2.84 U	2.93 U	2.9 U	2.93 U
Method FLA PRO											
	mg/L ^j										
TRPH ^m		5	50		0.21 U	0.21 U	22.1 J	0.21 U	0.21 U	0.21 U	0.21 U

Note: Shading denotes the target cleanup level (TCL) that was exceeded and the sample result that exceeds the TCL(s). Similarly, outlining denotes reporting limit exceeding TCL indicated.

^a FDEP, 1997

^b Target Cleanup level for No Further Action With and Without Conditions

^c Allowable maximum concentration for remediation by natural attenuation with monitoring

^d Screened interval depth in feet below ground surface

^e Replicate sample

^f µg/L = micrograms per liter.

^g NA = not available

^h U = not detected at the sample quantitation limit (SQL) shown (see Appendix D)

ⁱ J = detected at the estimated concentration shown (see Appendix D)

^j --- = not applicable.

^k MTBE = methyl tert-butyl ether

^l mg/L = milligrams per liter

^m TRPH = total recoverable petroleum hydrocarbons

detected at 73, 110, and 120 $\mu\text{g/L}$, respectively, in an October 1992 groundwater sample collected at MW-1. Based on these results, it appears that natural attenuation along with measurable BTEX reductions in source area soils, as a result of approximately 4 years of bioventing treatment, have significantly reduced BTEX concentrations in site groundwater.

The results of the PAH analysis using Method SW8310 indicate that four PAHs were present in source area groundwater (Table 3.2). In the sample collected from MW-1, benzo(a)anthracene was detected at a concentration of 2.28 $\mu\text{g/L}$, benzo(a)pyrene was detected at 2.5 $\mu\text{g/L}$, and fluorene was detected at an estimated concentration of 5.22J $\mu\text{g/L}$. Naphthalene was detected in both the primary and replicate samples from well DW-1 at concentrations of 20 and 19.8 $\mu\text{g/L}$, respectively. During pre-bioventing groundwater sampling events, no PAHs were detected at DW-1, but elevated concentrations of naphthalene (330 $\mu\text{g/L}$), 1-methylnaphthalene (240 $\mu\text{g/L}$), 2-methylnaphthalene (340 $\mu\text{g/L}$), and phenanthrene (66 $\mu\text{g/L}$) were detected at MW-1 (Appendix A, Table 2.3). Overall, PAH concentrations in source area groundwater appear to have been reduced at least 1 order of magnitude since 1992 through natural attenuation supplemented by more than 4 years of source area soils treatment.

As shown in Table 3.2, TRPH were detected at an estimated concentration of 22.1 J mg/L in the sample from MW-1, but was not detected at DW-1 or any of the perimeter monitoring wells (Figure 2.1). In comparison, TRPH were detected at 40.5 mg/L in the October 1992 groundwater sample collected from MW-1 (Appendix A, Table 2.3). Based on these results, the TRPH concentration in shallow source area groundwater appears to have decreased by approximately 46 percent between October 1992 and July 1998.

3.3 SOIL AND GROUNDWATER CLEANUP LEVELS

The *Petroleum Contamination Site Cleanup Criteria* (Chapter 62-770 of the Florida Administrative Code [FAC]) (FDEP, 1997) were developed as guidance for determining remedial requirements for closure of petroleum-contaminated sites, and are based on several mechanisms for determining matrix-specific cleanup criteria. The regulations allow closure of petroleum release sites under several different scenarios, including:

- NFA without conditions,
- NFA with conditions, or
- Monitoring only for natural attenuation.

Closure of a site under the NFA-without-conditions alternative allows unrestricted future use of the site, and therefore the requirements and allowable contaminant levels under this alternative are the most restrictive. The NFA-with-conditions alternative requires that appropriate institutional or engineering controls be implemented to limit receptor exposure to contaminated media; proponents seeking site closure under this

alternative are subject to potentially less stringent cleanup levels. Natural attenuation with monitoring (i.e., MNA) is a recognized means of remediating sites with petroleum hydrocarbon contamination in groundwater, with the goal of achieving the NFA TCLs. These options are defined further in the following subsections.

3.3.1 No Further Action Without Conditions

Closure of a petroleum release site under an NFA proposal without conditions requires that a site meet the following criteria (FDEP, 1997):

- No free-phase LNAPL is present;
- No fire or explosion hazard is present due to release of petroleum or petroleum products ;
- No "excessively contaminated soil" is present; and
- Matrix-specific TCLs for soil and groundwater are met.

Contaminant concentrations in all affected media at a site must be below all applicable TCLs for the site to qualify for a NFA without conditions proposal. The *Petroleum Contamination Site Cleanup Criteria* (FDEP, 1997) provides matrix-specific TCLs for petroleum constituents in the form of "look-up" tables. For soil contamination, TCLs are provided for direct-exposure and soil leachability scenarios. Level I direct-exposure values shown in Table 3.1 are the TCLs for soil at sites seeking NFA without conditions. For groundwater contamination, TCLs shown in Table 3.2 are the FDEP (1997) Table V values for groundwater resource protection and recovery.

To demonstrate that contaminated soil is not present in the unsaturated zone, representative soil samples must show that concentrations of the applicable petroleum constituents are less than the lower of the FDEP (1997) direct-exposure Level I or soil leachability TCLs. If leachability TCLs are exceeded, direct leachability testing may be performed to determine if leachate concentrations exceed the applicable groundwater target cleanup levels. In addition, the rule also allows for the development of alternative cleanup levels that can be used in place of those presented in the look-up tables. The alternative cleanup levels must be developed based on site-specific exposure scenarios and risk analysis.

3.3.2 No Further Action With Conditions

Closure of a petroleum release site under an NFA-with-conditions option requires that a site meet the first three criteria for NFA without conditions (Section 3.3.1); however, alternative TCLs may be justified by the property owner by agreeing to the enactment of institutional controls (i.e., land use restrictions) and/or engineering controls. For soil, less restrictive direct-exposure TCLs (Level II in Table 3.1) may be used, and the soil leachability TCLs may be exceeded if it can be demonstrated, based on site characteristics and restrictions specified in the institutional control, that petroleum constituents will not leach into groundwater at concentrations exceeding

applicable groundwater TCLs. For groundwater, alternative groundwater cleanup levels may be justified depending on the current and projected use of groundwater in the site vicinity and by enacting appropriate institutional controls.

3.3.3 Natural Attenuation With Monitoring

FDEP (1997) recognizes MNA as a viable site rehabilitation strategy. The following criteria must be met to demonstrate that this strategy is appropriate for a site:

- No free-phase LNAPL is present;
- Contaminated soil is not present or does not constitute a continuing source of contamination to groundwater;
- Groundwater contaminant concentrations above applicable TCLs are not migrating beyond a temporary point of compliance (POC);
- Contaminant concentrations in groundwater do not exceed FDEP (1997) Table IX MNA TCLs (Table 3.2); or technical evaluations (as specified in 62-770.690 (1)(f), FAC) indicate that MNA is an appropriate remedial alternative;
- Available data show an overall decrease in the mass of contamination over time; and
- MNA of site groundwater is anticipated to achieve the applicable NFA criteria in 5 years or less;

MNA requires the establishment of a temporary POC based on site-specific conditions relating to land and groundwater use, potentially exposed populations, hydrogeology, and types and concentrations of contaminants. If human health, public safety, and the environment are protected, the POC may be moved to the property boundary, or beyond the property boundary (with notice), if necessary to address current plume conditions.

3.4 COMPARISON OF CONFIRMATION SAMPLING RESULTS TO TARGET CLEANUP LEVELS

3.4.1 Soil

Based on findings from the July 1998 confirmation sampling event and previous soil sampling events, the soil leachability TCLs shown in Table 3.1 are likely to represent the primary cleanup criteria for soil. Soil headspace VOC measurements collected during the 1992 Phase I and II investigations (Appendix A, Tables 2.1 and 2.2) and during the July 1998 confirmation sampling event (Appendix B) indicate that minimal soil contamination exists in shallow soils between 0 and 4 feet bgs. The largest mass of petroleum-hydrocarbon contamination is present in soils from 5 to 7 feet bgs. As a result, direct human exposure to site soils likely represents less of a potential risk than does petroleum contaminant leaching from soil into groundwater. Therefore, the soil

leachability TCLs are the primary criteria for evaluating remediation progress and the readiness of site soils for an NFA recommendation.

As shown on Table 3.1, three analytes (total xylenes, benzo[a]anthracene, and TRPH) were detected in site soils at concentrations exceeding their respective soil leachability TCLs. Total xylenes were detected in four samples (SB3, SB4 and its replicate sample, and SB6) at concentrations as much as 2 times the soil leachability TCL of 300 $\mu\text{g}/\text{kg}$. Benzo(a)anthracene was detected in one sample (SB4) at a concentration of 3,000 $\mu\text{g}/\text{kg}$, which slightly exceeds the soil leachability TCL of 2,900 $\mu\text{g}/\text{kg}$. TRPH results for all 10 soil samples collected during the confirmation sampling event exceed the soil leachability TCL of 340 mg/kg . TRPH were detected at an average concentration of 6,500 mg/kg , more than 19 times the soil leachability TCL of 340 mg/kg . The maximum detected concentration of TRPH (12,674 mg/kg) is more than 37 times the TRPH soil leachability TCL. In addition, benzo(a)anthracene, benzo(a)pyrene, and TRPH were detected in site soils at concentrations exceeding direct-exposure TCLs. SQLs for three compounds (acenaphthylene, acenaphthene, and naphthalene) exceeded FDEP (1997) soil leachability TCLs as a result of sample analysis at higher dilution factors. Similarly, SQLs for four other compounds (benzo[a]pyrene, benzo[b]fluoranthene, dibenzo[a,h]anthracene, and indeno[1,2,3-cd]pyrene) exceeded FDEP (1997) direct exposure TCLs (Appendix C).

3.4.2 Groundwater

Groundwater analytical results from the July 1998 confirmation sampling event are compared to FDEP (1997) NFA and MNA cleanup levels in Table 3.2. Five analytes (benzene, ethylbenzene, benzo(a)anthracene, benzo(a)pyrene, and TRPH) were detected in the groundwater sample from MW-1 at concentrations exceeding the FDEP (1997) NFA TCLs. Groundwater analytical results from MW-1 were consistently less than the FDEP (1997) Table IX natural attenuation default source concentrations (Table 3.2), making the site a potential candidate for MNA of groundwater contamination, if the other conditions outlined in Section 3.3.3 can be demonstrated. No analytical results from the other five monitoring wells exceeded the NFA cleanup levels. The SQLs for benzene and several PAHs (acenaphthylene, acenaphthene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenzo[a,h]anthracene, indeno[1,2,3-cd]pyrene, and naphthalene) exceeded the NFA cleanup levels, but not the allowable maximum concentrations for MNA.

3.5 EVALUATION OF NATURAL ATTENUATION

To estimate the impact of natural attenuation processes (e.g., advection, dispersion, sorption, volatilization, and biodegradation) on the fate and transport of fuel contaminants dissolved in site groundwater, two important lines of evidence should be demonstrated (Wiedemeier *et al.*, 1995). The first is a documented loss of contaminants at the field scale. The second line of evidence involves the use of geochemical data to show that areas with fuel contamination can be correlated to areas with depleted electron acceptor (e.g., oxygen, nitrate, and sulfate) concentrations and increases in metabolic fuel degradation byproduct concentrations (e.g., methane,

sulfide, and ferrous iron). Confirmation sampling data supporting these two lines of evidence suggest that natural attenuation of dissolved fuel contaminants is occurring in site groundwater; however, estimated contaminant-mass reduction rates suggest that natural attenuation alone will not reduce all dissolved petroleum hydrocarbon contaminants to below NFA criteria in 5 years or less, as required to support a MNA proposal for the site (Section 3.3.3).

3.5.1 Contaminant Reduction Over Time

Reduction of contaminant concentrations in the source area over time are an indication that attenuation is occurring. Based on analytical data for samples collected from MW-1 (shallow source well) in October 1992 (Appendix A, Table 2.3) and July 1998 (Table 3.2), concentrations of detected fuel hydrocarbons in groundwater have decreased significantly. The benzene concentration decreased 90 percent (from 73 $\mu\text{g/L}$ to 7.3 $\mu\text{g/L}$), and the ethylbenzene concentration decreased 64 percent (from 110 $\mu\text{g/L}$ to 39.4 $\mu\text{g/L}$) over this period. MTBE and naphthalene concentrations decreased to nondetectable levels (however, note the high SQL for naphthalene [196 $\mu\text{g/L}$]). Less dramatic, but still significant, is the 46-percent decrease in TRPH at MW-1 (from 40.5 mg/L to 22.1 J mg/L) during this same period. Data prior to 1998 are not available for comparison of benzo(a)anthracene and benzo(a)pyrene, which were detected during confirmation sampling at concentrations exceeding their respective NFA TCLs (Table 3.2).

While site data are insufficient to enable accurate estimates of site-specific and analyte-specific biodegradation rates, the overall attenuation rate, including both nondestructive (advection, dispersion, sorption, volatilization) and destructive (biodegradation) processes, can be estimated assuming first-order decay. First-order decay is described by the following ordinary differential equation:

$$dC/dt = kt \quad \text{eq. 3.1}$$

Solving this differential equation yields:

$$C = C_0 e^{-kt} \quad \text{eq. 3.2}$$

Where: C = contaminant concentration at time t

C₀ = contaminant concentration at time "0"

k = first-order rate constant (years⁻¹)

e = base of natural logarithms (approximately 2.718282)

Solving equation 3.2 to obtain the first-order rate constant (i.e., overall attenuation rate constant) "k" gives:

$$k = -\ln(C/C_0)/t \quad \text{eq. 3.3}$$

Once "k" is known, the time "t" for a contaminant to reach a given concentration can be determined by rearranging equation 3.3:

$$t = -\ln(C/C_0)/k \quad \text{eq. 3.4}$$

Considering the October 1992 (Appendix A, Table 2.3) and July 1998 (Table 3.2) results for benzene, ethylbenzene, and TRPH at MW-1, the overall attenuation rate constants and time for each of these contaminants to reach the FDEP (1997) NFA TCLs in source area groundwater were estimated. Calculations are provided in Appendix E. For benzene, ethylbenzene, and TRPH, first-order attenuation rate constants of 0.4004, 0.1786, and 0.1053 years⁻¹, respectively, were determined using equation 3.3. Using these estimated attenuation rate constants, the time required to achieve the FDEP (1997) NFA TCLs for benzene (1 µg/L), ethylbenzene (30 µg/L), and TRPH (5 mg/L) were estimated using equation 3.4 and the July 1998 sample results at MW-1. Assuming benzene, ethylbenzene, and TRPH concentrations in source area groundwater continue to attenuate at the rate observed between October 1992 and July 1998, it will take approximately 5, 1.5, and 14 years, respectively, to achieve the FDEP (1997) NFA TCLs. It is important to note that approximately 4 years of soil bioventing treatment likely has enhanced the overall contaminant attenuation rates observed in source area groundwater between October 1992 and July 1998. Continued bioventing is expected to be necessary to maintain these first-order attenuation rates.

Time estimates for benzo(a)anthracene and benzo(a)pyrene to reach NFA TCLs in groundwater could not be determined because historical data for these contaminants are not available. Nonetheless, relatively high groundwater concentrations of benzo(a)anthracene and benzo(a)pyrene in source area groundwater (approximately 10 times the NFA TCLs), combined with attenuation rates that are expected to be slower than those observed for benzene and ethylbenzene, may prevent the attainment of the NFA TCLs for these compounds in 5 years or less.

3.5.2 Geochemical Evidence of Contaminant Biodegradation

Groundwater samples from Facility 1748 were analyzed for various geochemical indicators to provide evidence that contaminant biodegradation is occurring in site groundwater. An overview of the biodegradation processes commonly observed in groundwater at petroleum release sites is presented in this subsection, along with the analytical results for geochemical indicators at the site.

Microorganisms obtain energy for cell production and maintenance by facilitating thermodynamically advantageous redox reactions involving the transfer of electrons from electron donors to available electron acceptors. This results in the oxidation of the electron donor and the reduction of the electron acceptor. Electron donors at the site are natural organic carbon and fuel hydrocarbon compounds. Fuel hydrocarbons are completely degraded or detoxified if they are used as the primary electron donor for microbial metabolism (Bouwer, 1992). Electron acceptors are elements or compounds that occur in relatively oxidized states, and include DO, nitrate, ferric iron, sulfate, and carbon dioxide. The prime electron acceptor is DO, which is used first during aerobic

biodegradation. After the DO is consumed, anaerobic microorganisms typically use electron acceptors in the following order of preference: nitrate, ferric iron hydroxide, sulfate, and finally carbon dioxide.

Depending on the types and concentrations of electron acceptors present, the pH conditions, and the redox potential of groundwater at a petroleum-contaminated site, anaerobic biodegradation can occur by denitrification, ferric iron reduction, sulfate reduction, or methanogenesis. Other, less common anaerobic degradation mechanisms, such as nitrate or manganese reduction, may dominate if the physical and chemical conditions in the subsurface favor use of these electron acceptors. Anaerobic destruction of the BTEX and PAH compounds is associated with the accumulation of fatty acids, production of methane, solubilization of iron, and reduction of nitrate and sulfate (Cozzarelli *et al.*, 1990; Wilson *et al.*, 1990). Environmental conditions and microbial competition ultimately determine which processes will dominate. Vroblesky and Chapelle (1994) show that the dominant terminal electron accepting process can vary both temporally and spatially in an aquifer with fuel hydrocarbon contamination. July 1998 geochemical indicator results for Facility 1748 groundwater are presented in Table 3.3. The primary conclusions that can be drawn from these data are summarized in the following subsections.

3.5.2.1 Reduction/Oxidation Potential

Redox potential is a measure of the relative tendency of a solution to accept or transfer electrons. The redox potential of a groundwater system depends on which electron acceptors are being reduced by microbes during oxidation of hydrocarbons. The redox potential of groundwater at Facility 1748, based on July 1998 measurements, ranges from -340 millivolts (mV) at MW-1 to 129 mV at MW-6 (Table 3.3). Other than the redox potential measured at MW-6, redox measurements indicate site groundwater is strongly reducing. As shown on Figure 3.1, these redox potentials are within the range in which reduction of oxygen, nitrate, iron, sulfate, and carbon dioxide (methanogenesis) can occur (Stumm and Morgan, 1981; Norris *et al.*, 1994). As expected, the lowest redox potential was observed in the source area at MW-1, and coincides with elevated ferrous iron, sulfide, and methane concentrations at this location.

3.5.2.2 pH

Groundwater pH values measured at the site were relatively neutral, ranging from 6.88 to 7.74 standard units. These values are within the optimal range for fuel hydrocarbon-degrading microbes of 6 to 8 (Wiedemeier *et al.*, 1995).

3.5.2.3 Temperature

Temperature affects the types and growth rates of bacteria that can be supported in the groundwater environment, with higher temperatures generally resulting in higher growth rates. The temperature of groundwater samples collected from site monitoring

TABLE 3.3
JULY 1998 GEOCHEMICAL INDICATORS IN GROUNDWATER
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

		Well Identification and Screened Interval ^{a/}					
Analytical Method		MW-1	DW-1	MW-2	MW-6	MW-7	MW-9
Target Parameter	Units	2-12	25-35	2-12	2-12	3.6-13.6	3.6-13.6
Hach[®] Analyses							
Ferrous Iron	(mg/L) ^{b/}	0.22	0.01	0.06	0.12	0.39	0.09
Manganese	(mg/L)	0.3	0.2	0.4	0.1	0	0
Nitrate	(mg/L)	4.6	0.8	0.3	0.4	0.3	1.5
Nitrite	(mg/L)	0.027	0.05	0.027	0.026	0.008	0.046
Sulfide	(mg/L)	4.7	0.016	0.024	0	0.014	0.072
Laboratory Analyses^{c/}							
Methane	(mg/L)	8.27	--- ^{d/}	0.125	---	---	---
Sulfate	(mg/L)	88	9.2	9.8	16.9	38	96
Direct Measurement							
Conductivity	(μ S/cm) ^{e/}	0.818	0.641	0.453	0.554	0.585	0.767
Dissolved Oxygen	(mg/L)	0.11	0.13	0.25	0.28	0.21	0.17
Redox Potential ^{f/}	(mV) ^{g/}	-340	-288.9	-290.1	129.4	-147.7	-293.1
pH	standard units	7.13	7.47	7.26	7.24	7.74	6.88
Temperature	(°C) ^{h/}	29	26.5	26.4	30.4	29.7	29.8
Turbidity	(NTU) ^{i/}	16	0	1	13	6	0

^{a/} Screened interval in feet below ground surface.

^{b/} mg/L = milligrams per liter.

^{c/} Methane analysis by Robert S. Kerr Standard Operating Procedure 175; sulfate analysis by USEPA Method SW9056.

^{d/} --- = not applicable.

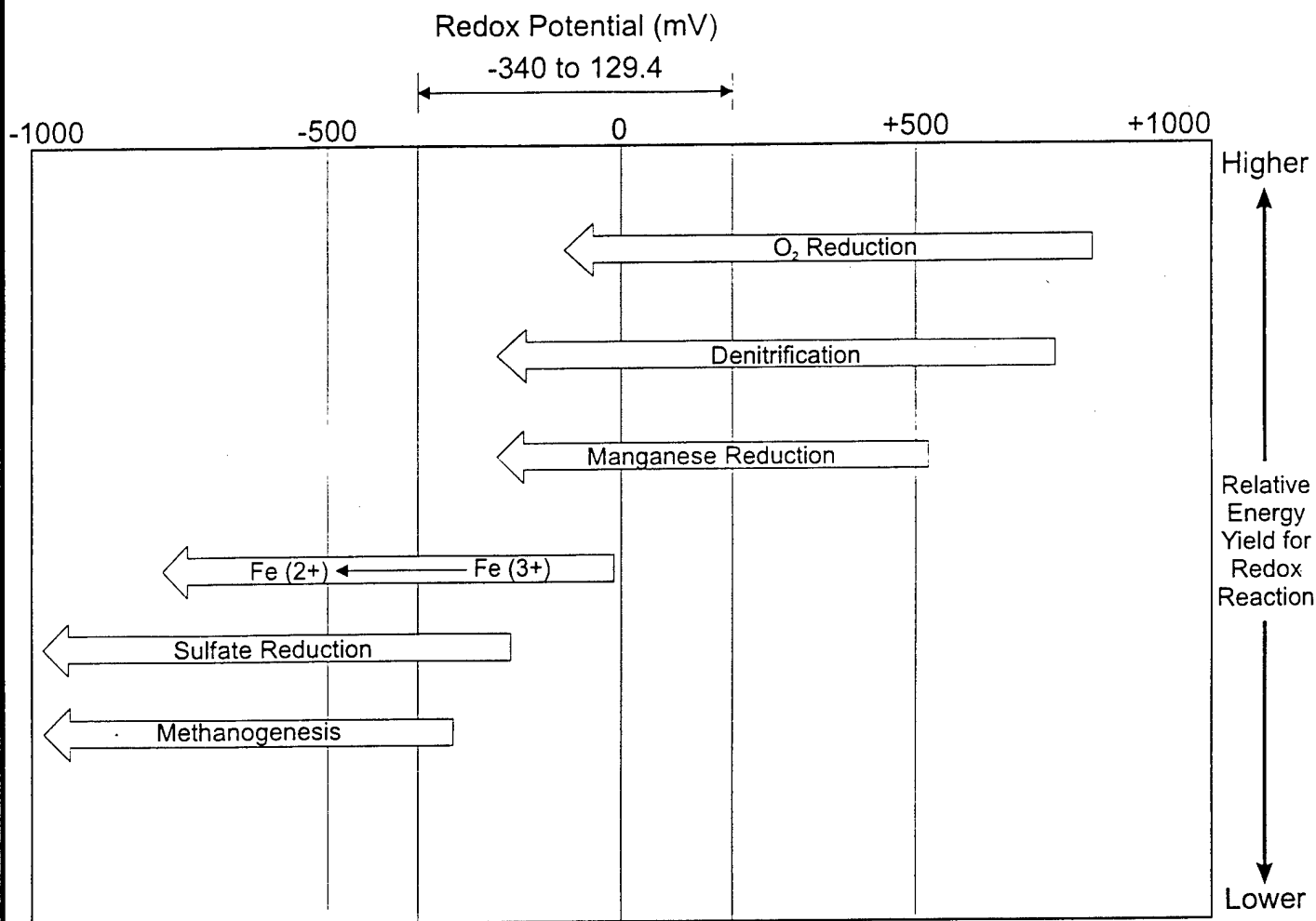
^{e/} μ S/cm = microsiemens per centimeter.

^{f/} Redox = reduction/oxidation.

^{g/} mV = millivolts.

^{h/} °C = Degrees Celsius.

^{i/} NTU = nephelometric turbidity unit.



Notes

Redox = Reduction/Oxidation

Range of redox potential measured at Facility 1748, Cape Canaveral AS

1. These reactions would be expected to occur in sequence if the system is moving toward equilibrium.
2. These redox processes occur in order of their energy-yielding potential (provided microorganisms are available to mediate a specific reaction). Reduction of a highly oxidized species decreases the redox potential of the system.
3. The redox potential of the system determines which electron acceptors are available for organic carbon oxidation.
4. Redox sequence is paralleled by an ecological succession of biological mediators.

FIGURE 3.1

SEQUENCE OF MICROBIOLOGICALLY MEDIATED REDOX PROCESSES

Facility 1748, SWMU 134
Cape Canaveral AS, Florida

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Adapted from Stumm and Morgan, 1981 and Norris *et al.*, 1994.

wells varied from 26.4 to 30.4°C. These relatively warm temperatures should promote microbial growth and may enhance rates of hydrocarbon biodegradation.

3.5.2.4 Dissolved Oxygen

Concentrations of DO were low (less than 1 mg/L) throughout the site, including at upgradient well MW-2 (0.25 mg/L). These data suggest that there is a limited supply of DO in groundwater flowing into the site, and that aerobic biodegradation of dissolved hydrocarbons probably is not a significant degradation mechanism in site groundwater. In addition, the strongly reducing conditions in site groundwater are not very favorable for aerobic biodegradation (Table 3.3 and Figure 3.1).

3.5.2.5 Nitrate

Nitrate can function as an electron acceptor in microbially facilitated fuel hydrocarbon degradation reactions only if the groundwater system has been depleted of oxygen (i.e., the groundwater must be functionally anaerobic). The highest nitrate concentration was detected at source area well MW-1 (4.6 mg/L). Nitrate concentrations in the perimeter wells did not exceed 1.5 mg/L. As with DO, there appears to be a limited supply of nitrate in groundwater flowing into the site. Redox conditions are not very favorable for denitrification. These results suggest that nitrate is not a significant electron acceptor in the degradation of dissolved hydrocarbons at this site.

3.5.2.6 Manganese

Manganese also can be used as an electron acceptor to facilitate the oxidation of fuel hydrocarbon compounds under anaerobic and slightly reducing conditions. Concentrations of reduced manganese ranged from 0 to 0.4 mg/L with the highest detection at the upgradient well MW-2. These results, combined with the strongly reducing conditions in site groundwater, suggest manganese reduction is not a significant biodegradation mechanism in site groundwater.

3.5.2.7 Ferrous Iron

The reduction of ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}) cannot proceed without microbial intervention (Lovley and Phillips, 1986). Ferrous iron concentrations in site groundwater ranged from 0.01 mg/L at DW-1 to 0.22 mg/L at MW-1. At the furthest upgradient well, MW-2, the ferrous iron concentration was 0.06 mg/L. Slightly elevated concentrations of ferrous iron measured in source area groundwater, relative to areas upgradient and crossgradient from the source area, are a strong indicator of microbial activity. The redox potential of site groundwater is in the range favorable for ferric iron reduction.

3.5.2.8 Sulfate/Sulfide

Sulfate may be used as an electron acceptor during microbial degradation of fuel hydrocarbons under anaerobic and strongly reducing conditions. Sulfide is a metabolic product of sulfate reduction, but is typically unstable, and unreliable for conclusive evaluation of this degradation pathway. Therefore, spatial differences in sulfate concentration in groundwater are typically used to evaluate sulfate reduction. While sulfate concentrations ranging from 9.2 mg/L to 96 mg/L are adequate to support hydrocarbon biodegradation through this mechanism, the sulfate results are inconsistent and do not strongly indicate that sulfate reduction is necessarily occurring. Nonetheless, the highest sulfide concentration (4.7 mg/L) was measured at MW-1, and the redox potentials of site groundwater are in the range favorable to sulfate reduction. These results indicate that microorganisms may be utilizing sulfate to facilitate the oxidation of fuel hydrocarbons in the source area.

3.5.2.9 Methanogenesis

Methane concentrations of 0.125 mg/L and 8.27 mg/L were detected in groundwater samples from upgradient well MW-2 and source area well MW-1, respectively. The elevated concentration of methane at MW-1 relative to that at upgradient well MW-2 indicates that methanogenesis (i.e., carbon dioxide reduction) is occurring in groundwater where conditions are sufficiently reducing and an organic carbon source (i.e., fuel contamination) is present.

3.5.2.10 Summary

The presence of metabolic byproducts resulting from the reduction of electron acceptors is evidence of petroleum hydrocarbon biodegradation. The data presented in the preceding subsections suggest that degradation of dissolved hydrocarbon compounds is occurring primarily through the microbially mediated processes of anaerobic iron reduction and methanogenesis. In addition, anaerobic sulfate reduction also may be contributing to biodegradation of dissolved fuel contaminants.

SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

4.1.1 Vadose Zone Soils

Soil analytical results from the July 1998 confirmation soil sampling event indicate that ethylbenzene and total xylenes concentrations in site soil have been reduced by approximately 1 order of magnitude, and TRPH concentrations have been reduced by 40 to 60 percent as a result of approximately 4 years of bioventing treatment. While significant reductions in petroleum hydrocarbon concentrations have occurred, total xylenes, benzo(a)anthracene, and TRPH remain in soils at concentrations exceeding FDEP (1997) soil leachability TCLs (Table 3.1). Average TRPH levels remaining in site soil (6,500 mg/kg) are approximately 19 times the soil leachability TCL of 340 mg/kg. Leachability testing was not performed on site soil samples to determine if leachate concentrations exceed the applicable groundwater TCLs; however, the presence of the soil contamination at the capillary fringe, and the groundwater sample results from MW-1 indicate that petroleum contaminants are leaching into source area groundwater at concentrations that exceed groundwater TCLs.

Soil gas sampling and *in situ* respiration testing performed in May 1996 during Option 1 testing indicated that continued bioventing treatment of site soils was necessary. While TVH and BTEX concentrations in soil gas were reduced by approximately 3 orders of magnitude during the initial 2 years of bioventing (Appendix A, Table 2.5), site soils returned to anoxic conditions when the bioventing system was shut down. In addition, microbial respiration and fuel biodegradation rates were reduced only slightly from pre-bioventing rates (Appendix A, Table 2.6). The July 1998 confirmation soil results indicate that the oxygen-demanding conditions observed in 1996 likely persist in site soils because of the high fraction of TRPH that remains. Biodegradation of the longer-chain, higher-molecular-weight hydrocarbons, including PAHs, while progressing in site soils, occurs more slowly than BTEX biodegradation. Site soils will continue to benefit from air injection bioventing treatment.

4.1.2 Groundwater

The majority of groundwater contamination is limited to the area near MW-1. At this well, benzene concentrations have decreased an order of magnitude, and ethylbenzene concentrations have decreased more than 60 percent since 1992 (Table

3.2, and Appendix A, Table 2.3). Xylene levels at this well have decreased 2 orders of magnitude to near nondetectable concentrations, and similar decreases were observed for naphthalene over this same time period. Based on the natural attenuation analyses, biodegradation of the fuel hydrocarbons are occurring primarily through processes of anaerobic iron reduction and through methanogenesis. Some biodegradation also may be occurring through anaerobic sulfate reduction, but the sulfate results did not provide conclusive evidence of this degradation pathway.

Although significant decreases in hydrocarbon contamination have been observed in groundwater at the site, several compounds are present at concentrations that exceed FDEP (1997) NFA criteria. Benzene, ethylbenzene, benzo(a)anthracene, benzo(a)pyrene, and TRPH were detected at MW-1 at concentrations exceeding the FDEP (1997) NFA TCLs for groundwater (Table 3.2). Concentrations of these contaminants did not exceed the FDEP (1997) natural attenuation default source values (Table 3.2); however, a MNA-only proposal for the site, in accordance with FDEP (1997) requirements (Section 3.3.3), does not appear to be currently viable due to the estimated time to meet NFA criteria. Considering the July 1998 concentration of TRPH at MW-1 (22.1 J mg/L) and observed contaminant reduction rates, TRPH levels will not reach the NFA TCL of 5 mg/L within 5 years, as required for implementation of this alternative. Observed attenuation rates indicate that it may take more than 10 years for TRPH levels in source area groundwater to be reduced to 5 mg/L. Benzo(a)anthracene and benzo(a)pyrene attenuation rates could not be estimated because groundwater data preceding the July 1998 sampling event are not available for these two analytes. Benzene, and ethylbenzene concentrations in source area groundwater likely will be reduced to NFA TCLs within 5 years.

4.2 RECOMMENDATIONS

Continued operation and monitoring of the bioventing system at Facility 1748 is recommended to further reduce petroleum hydrocarbon concentrations in site soils and to reduce contaminant leaching to groundwater. Because the contamination remaining in site soils is composed primarily of longer-chain, higher-molecular-weight hydrocarbons which are slower to biodegrade, several additional years of bioventing system operation may be required before static soil gas oxygen concentrations exceed 5 percent, or respiration and fuel biodegradation rates become asymptotic. Air injection bioventing is not expected to reduce soil TRPH levels below the soil leachability TCL of 340 mg/kg. This would require the average TRPH concentration remaining in site soils (6,500 mg/kg) to be reduced by 95 percent. However, air injection bioventing is expected to reduce the loading of petroleum hydrocarbon contaminants into site groundwater, which should hasten attainment of the groundwater NFA TCLs. Once these TCLs are attained, a NFA proposal may be submitted. The following specific actions are recommended for continued treatment and evaluation of soils at Facility 1748:

- Continue operation and monitoring of the bioventing system;

- Conduct soil gas sampling and respiration testing every 2 years to monitor remediation progress (because the latest soil gas sampling and respiration testing event was performed in May 1996, the first bi-annual event should be performed as soon as possible); and
- Collect and analyze additional soil samples once static oxygen concentrations in site soil gas exceed 5 percent, respiration rates become asymptotic, or groundwater monitoring results indicate petroleum hydrocarbon contaminants are no longer leaching into site groundwater at concentrations exceeding the NFA TCLs for groundwater (It is recommended that any future confirmation soil sampling include leachability testing for those contaminants detected in soils at concentrations exceeding the soil leachability TCLs).

If monitoring results following 2 to 4 years of additional bioventing treatment indicate that bioventing is not effectively reducing the loading of petroleum hydrocarbon contaminants to groundwater, another remedial process, such as excavation of source area soils, may be necessary. Establishment of alternative TCLs represents another possible option for consideration if continued bioventing is only marginally effective.

Groundwater sampling is recommended every 2 years at wells MW-1, DW-1, and at well MW-5 as a downgradient POC. Groundwater analytical results should be used to monitor contaminant reductions in the immediate source area, near the former diesel fuel UST. Laboratory analyses should include BTEX by USEPA Method SW8021B, PAHs by USEPA Method SW8310, and TRPH by Method FLA PRO.

SECTION 5

REFERENCES

- Bouwer, E.J., 1992. Bioremediation of Subsurface Contaminants. In R. Mitchell, editor, Environmental Microbiology. Wiley-Liss, New York. pp 287-318.
- CH2M Hill, 1994. Contamination Assessment Report, Facility 1748, Cape Canaveral Air Station. Tampa, Florida. August.
- CH2M Hill, 1995. Contamination Assessment Report Addendum, Response to FDEP Comments, Facility 1748, Cape Canaveral Air Station. Tampa, Florida. June.
- Cozzarelli, I.M., R.P. Eganhouse, and M.J. Baedecker, 1990. Transformation of Monoaromatic Hydrocarbons to Organic Acids in Anoxic Groundwater Environment. Environmental Geological Water Science, 16.
- Engineering Science, Inc. (ES), 1994. Draft Interim Pilot Test Results Report for Facilities 1748, 44625D, and Facility 44625E, Cape Canaveral AFS, Florida. Denver, Colorado. May.
- Florida Department of Environmental Protection (FDEP), 1997. Petroleum Contamination Site Cleanup Criteria, Chapter 62-770, Florida Administrative Code. Effective September 23, 1997.
- Lovley, D. R., and E. J. P. Phillips, 1986. Availability of Ferric Iron for Microbial Reduction in Bottom Sediments of the Freshwater Tidal Potomac River. Applied Environmental Microbiology. 52: 751-757.
- Norris, R.D., R.E. Hinchee, R. Brown, P.L. McCarty, L. Semprini, J.T. Wilson, D.H. Kampbell, M. Reinhard, E.H. Bouwer, R.C. Borden, T.M. Vogel, J.M. Thomas, and C.H. Ward, 1994. Handbook of Bioremediation: Lewis Publishers, Inc. 257 p.
- Parsons Engineering Science, Inc. (Parsons ES), 1996a. Letter Report to AFCEE/ERT, Final Tables and Example Letter of Transmittal for AFCEE Bioventing Test Initiative re: Facilities 1748, 44625D, and 44625E at Cape Canaveral AFS, Florida. Denver, Colorado. 13 February.
- Parsons ES, 1996b. Installation Restoration Program Remedial Action Plan, Base Cafeteria, Facility 1748 (SWMU 134), Cape Canaveral Air Station, Florida. Winter Park, Florida. July.

- Parsons ES, 1996c. Letter Report to AFCEE/ERT, Extended Bioventing Testing Results at Fire Training Area 2 (FTA-2), Patrick Air Force Base (AFB); and FTA-2 and Facility 1748, Cape Canaveral Air Force Station (AFS), Florida. Denver, Colorado. 12 July.
- Parsons ES, 1998. Final Confirmation Sampling and Analysis Plan for Facility 1748. SWMU 134, Cape Canaveral Air Station, Florida. Denver, Colorado. June.
- Stumm, W. and J.J. Morgan. 1981. Aquatic Chemistry. John Wiley & Sons. New York.
- Vroblesky, D.A., and F.H. Chapelle, 1994. Temporal and Spatial Changes of Terminal Electron-Accepting Processes in a Petroleum Hydrocarbon-Contaminated Aquifer and the Significance for Contaminant Biodegradation. Water Resources Research. v. 30. no. 5. pp. 1561-1570.
- Wiedemeier, T.H., J.T. Wilson, D.H. Kampbell, R.S. Miller, and J.E. Hansen, 1995. Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater. Revision 0. Prepared for Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas. Denver, Colorado. November.
- Wilson, B.H., J.T. Wilson, D.H. Kampbell, B.E. Bledsoe, and J.M. Armstrong, 1990. Biotransformation of Monoaromatic and Chlorinated Hydrocarbons at an Aviation Gasoline Spill Site. Geomicrobiology Journal. v. 8. pp. 225-240.

APPENDIX A
CONFIRMATION SAMPLING AND ANALYSIS PLAN

FINAL

Confirmation Sampling and Analysis Plan for Facility 1748, SWMU 134



**Cape Canaveral Air Station
Florida**

Prepared For

**Air Force Center for Environmental Excellence
Brooks Air Force Base, Texas**

and

**45 CES/CEV
Patrick Air Force Base, Florida**

June 1998



**PARSONS
PARSONS ENGINEERING SCIENCE, INC.**

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FINAL
CONFIRMATION SAMPLING AND ANALYSIS PLAN
FOR FACILITY 1748, SWMU 134
CAPE CANAVERAL AIR STATION, FLORIDA

Prepared for:

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ACRONYMS AND ABBREVIATIONS

45 CES/CEV	45th Civil Engineering Squadron/Environmental Flight
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
AS	Air Station
AST	aboveground storage tank
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
°C	degrees centigrade
CAR	contamination assessment report
CMS	corrective measures study
COPC	chemical of potential concern
DCE	dichloroethene
DO	dissolved oxygen
DOT	US Department of Transportation
ES	Engineering-Science, Inc.
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
HVW	horizontal vent well
IRP	Installation Restoration Program
LNAPL	light nonaqueous-phase liquid
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
MP	monitoring point
MTBE	methyl tert-butyl ether
mV	millivolts
NFA	no further action
PAH	polynuclear aromatic hydrocarbon
PAMP	Petroleum Action Management Plan
Parsons ES	Parsons Engineering Science, Inc.
PID	photoionization detector
POC	point of compliance
ppmv	parts per million, volume per volume
QC	quality control
RAP	remedial action plan
RCRA	Resource Conservation and Recovery Act
redox	reduction oxidation
RFI	RCRA facility investigation
RSKSOP	Robert S. Kerr (Laboratory) Standard Operating Procedure
SAP	Sampling and Analysis Plan

SWMU	solid waste management unit
TMW	temporary monitoring well
TRPH	total recoverable petroleum hydrocarbons
TVH	total volatile hydrocarbons
TVHA	total volatile hydrocarbon analyzer
USCS	Unified Soil Classification System
USEPA	US Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound
VW	vent well
WT	water table

SECTION 1

INTRODUCTION

This confirmation sampling and analysis plan (SAP) for Facility 1748, Solid Waste Management Unit (SWMU) 134, at Cape Canaveral Air Station (AS), Florida has been prepared by Parsons Engineering Science, Inc. (Parsons ES) for submittal to the Florida Department of Environmental Protection (FDEP); the US Air Force Center for Environmental Excellence (AFCEE), Brooks AFB, Texas; and 45th Civil Engineering Squadron/Environmental Flight (45 CES/CEV), Patrick Air Force Base (AFB), Florida. The SAP is intended to guide soil and groundwater sampling at Facility 1748 to document the effectiveness of remediation of petroleum-hydrocarbon-contaminated soils and to support a no-further-action (NFA) proposal for the site, or a monitoring-only proposal for natural attenuation, if appropriate. Facility 1748 is a Base cafeteria where petroleum-contaminated soils in the vicinity of a former 4,000-gallon underground storage tank (UST) were discovered in 1992. Petroleum-contaminated soils at the site are thought to have resulted from historical overfilling of the diesel fuel tank, which was in service from 1958 until March 1992.

As part of the AFCEE Bioventing Initiative, Parsons ES (formerly Engineering-Science, Inc. [ES, 1993]) installed a pilot-scale bioventing system at Facility 1748 in December 1993, and performed initial and extended pilot testing to determine if *in situ* bioventing would be a feasible cleanup technology for source area petroleum-contaminated soils within the unsaturated zone (ES, 1994, Parsons ES, 1996a). The 18-month pilot test demonstrated that bioventing was an effective treatment technology for petroleum-contaminated soils, and as a result, the site was included in the AFCEE Extended Bioventing Project. In September 1994, Facility 1748 was funded for an additional year of extended bioventing system operation followed by soil gas sampling and *in situ* respiration testing (Option 1). In addition, the Extended Bioventing project provided funding for confirmation/closure sampling (Option 2) following sufficient bioventing treatment.

Soil gas sampling and respiration testing was performed in May/June 1996 following the 1-year of AFCEE-funded extended bioventing system operation. While soil gas sampling results indicated that little volatile petroleum hydrocarbon contamination remained in site soils, respiration testing results indicated that fuel biodegradation was still occurring, and site soils would continue to benefit from air injection bioventing treatment (Parsons ES, 1996c). Based on these results, it was recommended that the bioventing system remain in operation. In November 1996, the vertical vent well (VW) that had been installed during the initial pilot test was replaced with a horizontal vent well (HVW) to ensure oxygenation of vadose zone soils year-round, even during periods of elevated water table conditions. Considering the low concentrations of total

volatile hydrocarbons (TVH), benzene, toluene, ethylbenzene, and xylenes (BTEX) in soil gas following 2 years of air injection into the VW and more than 1 year of HVW air injection, petroleum hydrocarbon concentrations in vadose zone soils are likely to meet revised FDEP (1997b) soil cleanup target levels which appear in Chapter 62-770 of the Florida Administrative Code (FAC), as listed in Section 3 of this SAP.

The objective of the confirmation sampling is to support a NFA proposal for soils and groundwater contaminated by diesel fuel from the former UST at Facility 1748. The proposed confirmation sampling described in Section 4 targets unsaturated and smear zone soils and groundwater in the vicinity of the former UST. It is anticipated that soil and groundwater analytical results will meet FDEP (1997b) risk-based criteria for NFA, or groundwater monitoring only, and no further soil remediation will be necessary.

This SAP consists of nine sections, including this introduction. Section 2 includes a site description and history, and summaries of previous investigations and remediation activities. Section 3 summarizes cleanup requirements for Facility 1748. A detailed SAP is presented in Section 4. Analytical results and recommendations for NFA, natural attenuation monitoring-only, or additional remedial action will be presented in a confirmation sampling report, as described in Section 5. Section 6 lists Patrick AFB support requirements, and Section 7 presents the proposed project schedule. Air Force, regulatory, and contractor points of contact are provided in Section 8, and cited references are provided in Section 9.

SECTION 2

SITE DESCRIPTION

2.1 SITE LOCATION AND HISTORY

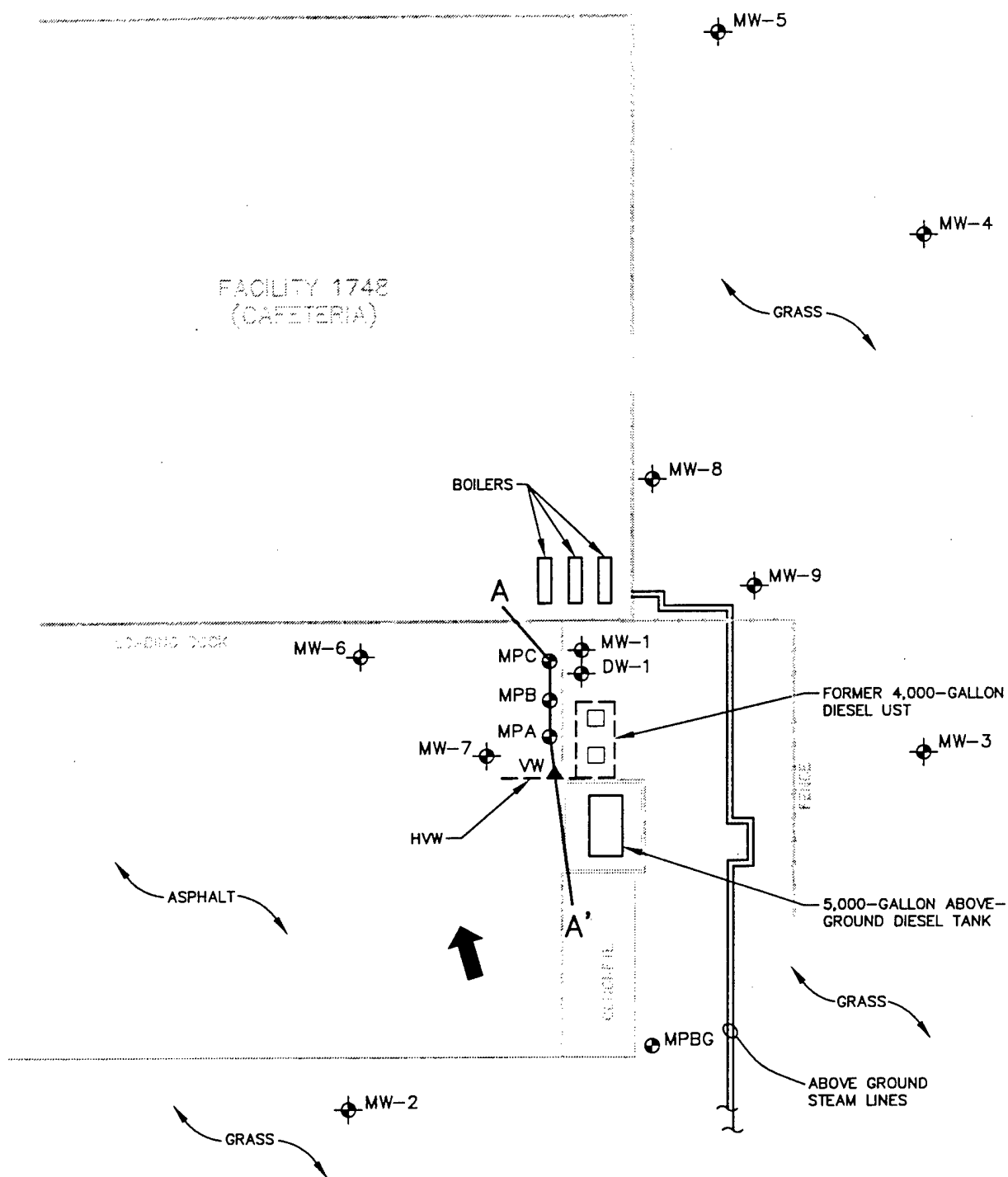
Facility 1748, a Base cafeteria, is located on Hangar Road within the industrial portion of Cape Canaveral AS (Figure 2.1). A layout of the Facility 1748 site is provided on Figure 2.2. The facility has been in operation since 1958. On the south side of Facility 1748, a 4,000-gallon UST was installed during facility construction and was used to store diesel fuel for the cafeteria boilers until March 1992. The UST was replaced by an aboveground storage tank (AST) in May 1992. The UST and the associated piping were removed by a contractor in December 1993.

2.2 SITE GEOLOGY AND HYDROGEOLOGY

Cape Canaveral AS is located on the barrier island system along the east coast of Florida in Brevard County, between the Banana River and the Atlantic Ocean (Figure 2.1). Two primary aquifers are present within this region, an unconfined surficial aquifer and the confined Floridian Aquifer. Water enters the surficial aquifer through direct infiltration and percolation of rainwater, and typically moves laterally toward the ocean or the river. Water contained in the Floridian Aquifer is under artesian pressure, exhibiting hydraulic heads approximately 0 to 10 feet above ground surface at Cape Canaveral AS, which results in an upward gradient between the Floridian and surficial aquifers.

Groundwater in the surficial aquifer generally is classified by the State of Florida as Class G-II (suitable for potable use with a total dissolved solids content less than 10,000 milligrams per liter [mg/L]). At Cape Canaveral AS, neither the surficial aquifer nor the Floridian Aquifer are used for potable water supply. The Station receives its potable water from the City of Cocoa from a source in east Orange County (Parsons ES, 1996b). A secondary potable water supply is available for the Station through Patrick AFB and the City of Melbourne. Although emergency potable wells are located on Cape Canaveral AS, no routinely used potable wells are located within a 1-mile radius of the facility.

At Facility 1748, the shallow aquifer is encountered at fluctuating depths between 2.5 and 8 feet below ground surface (bgs). During installation of the pilot-scale bioventing system in December 1993, the shallow water table measured approximately 6.5 feet bgs; however, during extended bioventing system operation at the site, the water table has measured as high as 2.5 feet bgs during the "rainy season." Groundwater flow in the shallow aquifer at Facility 1748 is generally to the north-



LEGEND

- MW-1 GROUNDWATER MONITORING WELL
- MPA VAPOR MONITORING POINT
- VW VERTICAL AIR INJECTION VENT WELL
- HW HORIZONTAL AIR INJECTION VENT WELL
- A-A' HYDROGEOLOGIC CROSS SECTION LOCATION (FIGURE 2.3)



GROUNDWATER FLOW DIRECTION



FIGURE 2.2

SITE LAYOUT

Facility 1748, SWMU 134
Cape Canaveral AS, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

northeast (CH2M Hill, 1994 and 1995). Soils within the surficial aquifer consist of fine- to coarse-grained quartz sand with coquina and shell fragments at increasing depths (Figure 2.3).

2.3 PREVIOUS SITE INVESTIGATIONS

2.3.1 Phase I and II Investigations

A Phase I contamination assessment of Facility 1748 was conducted during January 1992 by CH2M Hill (1994) to address the potential soil and groundwater contamination associated with the diesel fuel UST. Based on Phase I investigation results, CH2M Hill performed a Phase II investigation in October 1992 to further delineate the extent of soil and groundwater contamination identified during the Phase I investigation. Results of the investigations were documented by CH2M Hill (1994) in a Contamination Assessment Report (CAR).

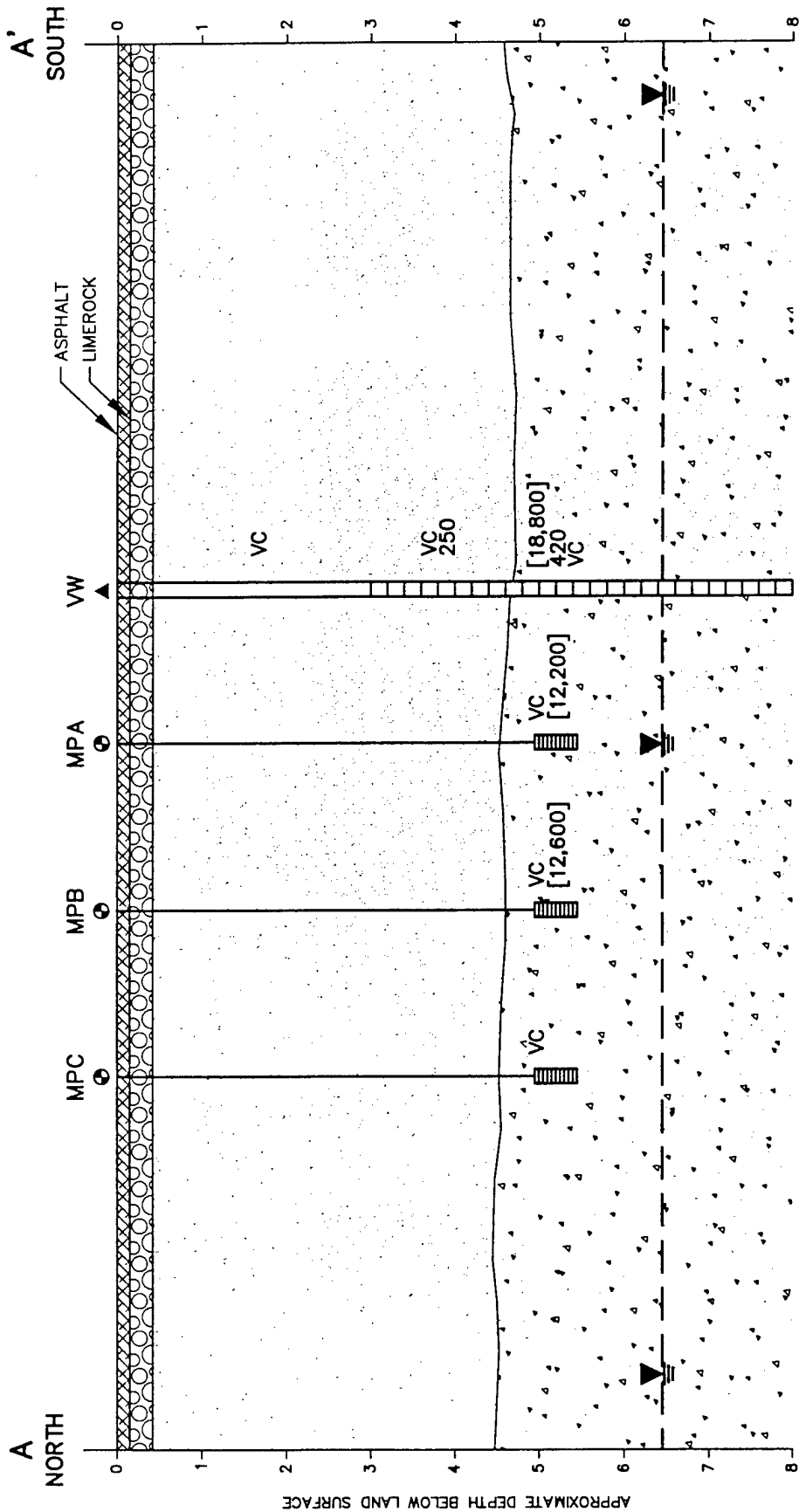
2.3.1.1 Soil Contamination

Hand-augered soil samples were collected near Facility 1748 during the Phase I and Phase II investigations. Soil samples from 15 soil borings (B-1 through B-15) during the Phase I investigation, and 9 additional soil borings (B-16 through B-24) during the Phase II investigation, were sampled and analyzed. Soil boring locations are shown on Figure 2.4. Soil samples were screened in the field for total hydrocarbon vapors using prescribed headspace analysis methods. Results of the soil headspace measurements for the Phase I and Phase II investigations are presented in Tables 2.1 and 2.2, respectively. Petroleum contaminated soil, with soil headspace measurements greater than 100 parts per million, volume basis (ppmv), was identified in the unsaturated zone samples from B-1, B-7, B-17, and B-18, and seven additional soil borings also indicated contaminated soils were reported in the saturated zone. The approximate extent of unsaturated and saturated zone soil contamination is illustrated on Figure 2.4.

2.3.1.2 Groundwater Contamination

During the Phase I investigation, five temporary monitoring wells (TMW-1 through TMW-5) were installed in five of the original soil boring locations (B-4, B-8, B-2, B-7, and B-15, respectively). Groundwater sampling results from the TMWs indicated petroleum contamination was present in site groundwater, and six shallow monitoring wells (MW-1 through MW-6) and one deep monitoring well (DW-1) were installed subsequent to the Phase I investigation. The shallow/deep monitoring well pair (MW-1/DW-1) were installed in the location of the former UST. MW-2 was installed as a background well, and the remaining wells were installed to characterize the lateral and downgradient extents of the dissolved hydrocarbon plume. The newly installed monitoring wells were initially sampled during Phase II investigations in October 1992. Groundwater sampling results from the Phase II investigation and more recent sampling events are presented in Table 2.3.

Groundwater sample results from the shallow source area well (MW-1) indicated significant concentrations of total BTEX (303 micrograms per liter [$\mu\text{g/L}$]), total recoverable petroleum hydrocarbons (TRPH) (40.5 mg/L), methyl tert-butyl ether



LITHOLOGIC DESCRIPTIONS

FINE-TO MEDIUM SAND
 FINE-TO MEDIUM SAND
 FINE-TO MEDIUM SAND

LEGEND

- PERMANENT MONITORING POINT SCREENED INTERVAL
- VENT WELL SCREENED INTERVAL
- VAPOR MONITORING POINT
- AIR INJECTION VENT WELL
- WATER TABLE SURFACE
- VC [12,600] LAB RESULTS FOR SOIL TOTAL PETROLEUM HYDROCARBONS (mg/kg)
- VC [12,200] FIELD SCREENING RESULTS FOR SOIL TOTAL VOTILE HYDROCARBONS (ppmv)
- VC [18,800] NOTE: WATER TABLE DEPTH SHOWN WAS ESTIMATED ON 12/23/93 DURING VENT WELL CONSTRUCTION

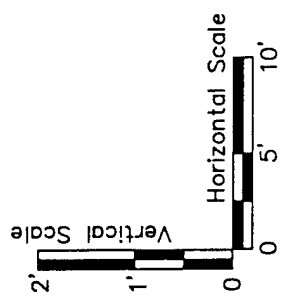


FIGURE 2.3

HYDROGEOLOGIC CROSS-SECTION

Facility 1748, SWMU 134
 Cape Canaveral AS, Florida

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 Denver, Colorado

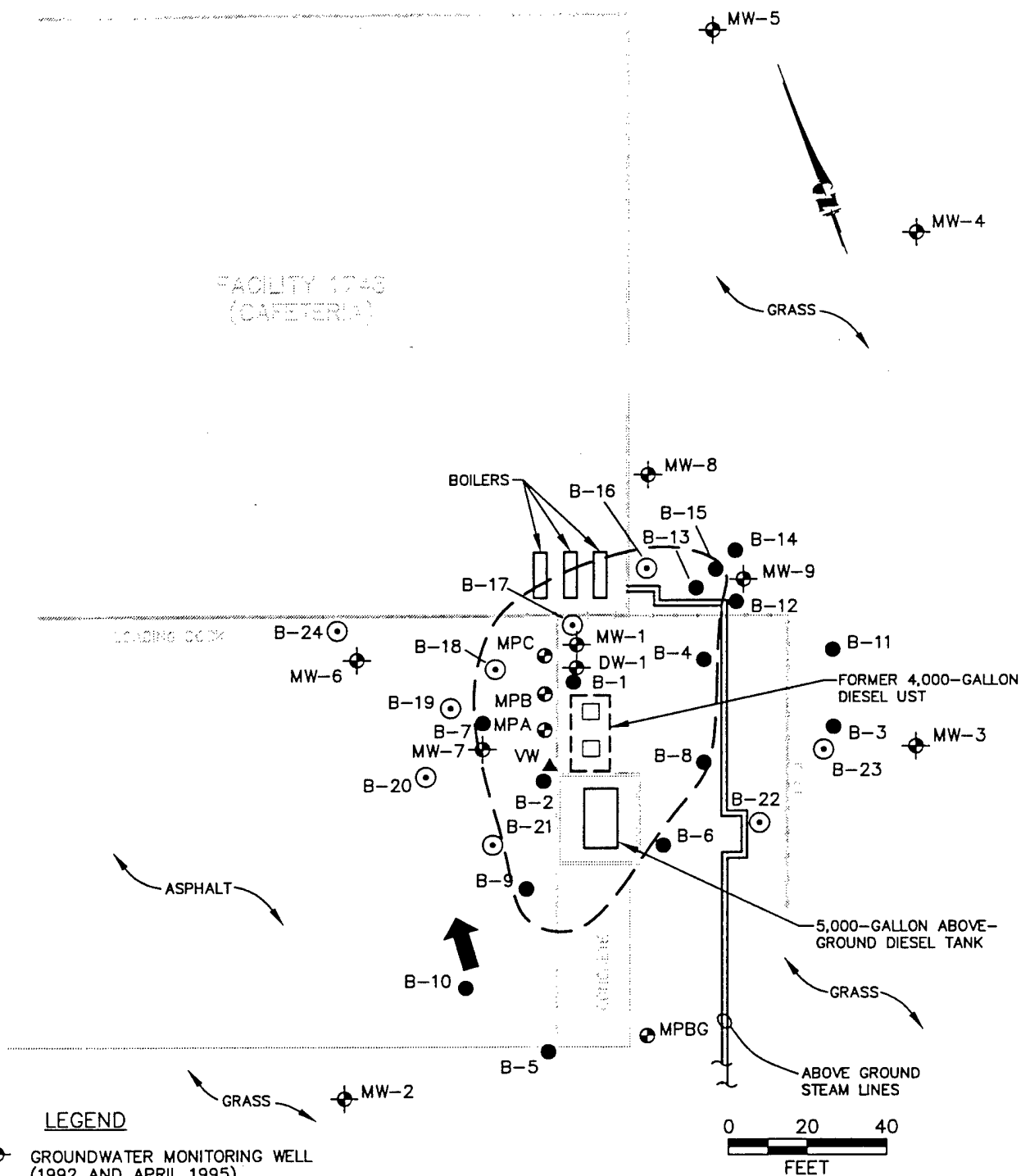


FIGURE 2.4

EXTENT OF SATURATED AND UNSATURATED SOIL CONTAMINATION

Facility 1748, SWMU 134
Cape Canaveral AS, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

TABLE 2.1
PHASE I SOIL HEADSPACE MEASUREMENTS
(JANUARY 1992)
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Location	Depth (feet bgs) ^{a/}	Total Hydrocarbons (ppmv) ^{b/}	Methane (ppmv)	Petroleum- Related Hydrocarbons (ppmv)	Comments
B-1	2	15	6	9	
	4	200	100	100	slight petroleum odor
	6	350	300	50	
	8	> 1000	> 1000	ND ^{c/}	saturated zone & strong petroleum odor
B-2	2	0	--- ^{d/}	0	TMW-3
	4	0	---	0	
	6	> 1000	> 1000	ND	saturated zone & strong petroleum odor
B-3	2	0	---	0	
	4	0	---	0	
	6	0	---	0	
B-4	2	0	---	0	TMW-1
	4	0	---	0	
	6	6.5	---	5.5	
	7	> 1000	> 1000	ND	free phase hydrocarbons in well
B-5	2	0	---	0	
	4	0	---	0	
	6	0	---	0	saturated zone
B-6	2	0	---	0	
	4	0	---	0	
	6	0	---	0	saturated zone
B-7	2	60	15	45	TMW-4
	4	200	100	100	slight petroleum odor
	6	60	22	38	saturated zone
B-8	2	0	---	0	TMW-2
	4	0	---	0	
	6	600	15	585	saturated zone & strong petroleum odor
B-9	2	0	---	0	
	4	0	---	0	
	6	> 1000	600	> 400	saturated zone & strong petroleum odor
B-10	2	0	---	0	
	4	0	---	0	
	6	0	---	0	saturated zone
B-11	2	0	---	0	
	4	0	---	0	
	6	0	---	0	
	7	5	---	5	saturated zone
B-12	2	0	---	0	
	4	0	---	0	
	6	0	---	0	
	7	20	---	20	saturated zone
B-13	2	0	---	0	
	4	0	---	0	
	6	50	0	50	musty odor
	7	> 1000	800	> 200	saturated zone & strong petroleum odor
B-14	2	0	---	0	
	4	0	---	0	
	6	0	---	0	
	7	0	---	0	saturated zone
B-15	2	0	---	0	TMW-5
	4	0	---	0	
	6	0	---	0	
	7	100	---	100	saturated zone

Source: Parsons ES, 1996b.

a/ bgs = below ground surface.

b/ ppmv = parts per million, volume per volume, above background readings.

c/ ND = not determined.

d/ --- carbon filter not used.

TABLE 2.2
PHASE II SOIL HEADSPACE MEASUREMENTS
(OCTOBER 1992)
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Location	Depth (feet bgs) ^{a/}	Total Hydrocarbons (ppmv) ^{b/}	Methane (ppmv)	Petroleum- Related Hydrocarbons (ppmv)	Comments
B-16	2	0	--- ^{c/}	0	saturated zone & strong petroleum odor
	4	0	---	0	
	6	> 1000	> 1000	ND ^{d/}	
B-17	2	600	150	450	medium petroleum odor
	4	400	100	300	saturated zone & strong petroleum odor
	6	> 1000	> 1000	ND	
B-18	2	> 1000	600	ND	strong petroleum odor
	4	850	200	650	medium petroleum odor
	6	> 1000	> 1000	ND	saturated zone & strong petroleum odor
B-19	2	0	---	0	saturated zone
	4	0	---	0	
	6	0	---	0	
B-20	2	0	---	0	saturated zone
	4	0	---	0	
	6	0	---	0	
B-21	2	0	---	0	saturated zone
	4	0	---	0	
	6	0	---	0	
B-22	2	0	---	0	saturated zone
	4	0	---	0	
	6	0	---	0	
B-23	2	0	---	0	saturated zone
	4	0	---	0	
	6	0	---	0	
B-24	2	26	---	26	saturated zone
	4	0	---	0	
	6	0	---	0	

Source: Parsons ES, 1996b.

a/ bgs = below ground surface.

b/ ppmv = parts per million, volume per volume, above background readings.

c/ --- carbon filter not used.

d/ ND = not determined.

TABLE 2.3
GROUNDWATER ANALYTICAL RESULTS
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Screened Interval (feet bgs) ^{a/} Analyte (µg/L) ^{b/}	Source Wells			Perimeter Wells								
	DW-1 ^{b/}	MW-1 ^{c/}	MW-2	MW-3		MW-4		MW-5	MW-6 ^{d/}	MW-7 ^{e/}	MW-8	MW-9
	25-35	2-12		2-12	2-12	2-12	2-12	2-12	2-12	2-12	2-12	2-12
	19-Aug-93	11-Apr-95	22-Oct-92	22-Oct-92	19-Aug-93	22-Oct-92	19-Aug-93	22-Oct-92	19-Aug-93	19-Aug-93	11-Apr-95	11-Apr-95
Benzene	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	<10	<1	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ethylbenzene	<10	<1	110	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Xylenes	<10	<1	120	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total BTEX	<40	<4	303	<4	<4	<4	<4	<4	<4	<4	<4	<4
1,1-Dichloroethene	--- ^{b/}	<1	---	---	---	---	---	---	---	---	1.8	<1
cis-1,2-Dichloroethene	12	22	<10	<1	---	<1	---	---	<1	---	11	3.2
trans-1,2-Dichloroethene	---	1.9	---	---	---	---	---	---	---	---	<1	<1
Vinyl Chloride	180	34	<10	<1	---	<1	---	<1	<1	---	1.4	<1
MTBE ^{b/}	<10	<10	45	<1	<1	<1	<1	<1	<1	<1	<1	<1
TRPH ^{b/}	0.19	<1	40.5	0.23	---	0.21	---	0.22	---	---	<1	<1
Lead (total)	2	---	30	25	---	5	---	13	---	---	27.9	8.5
1,2-Dibromomethane	---	<0.02	---	---	---	---	---	---	---	---	<0.02	<0.02
Naphthalene	<2	<2	330	<2	<1	<2	<1	<2	<1	<1	<2	3.4
2-Methylnaphthalene	<2	<2	340	<2	<1	<2	<1	<2	<1	<2	<2	23
1-Methylnaphthalene	<2	<2	240	<2	<1	<2	<1	<2	<1	<2	<2	30
Total Naphthalenes	<6	<6	910	<6	<3	<6	<3	<6	<3	<3	<6	3.4
Acenaphthene	---	<2	---	---	---	---	---	---	---	---	<2	<2
Acenaphthylene	---	<2	---	---	---	---	---	---	---	---	<2	<2
Fluorene	---	<2	---	---	---	---	---	---	---	---	<2	<2
Phenanthrene	<2	<2	66	<2	---	<2	---	<2	---	---	<2	<2

Source: Parsons ES, 1996b.

^{a/} feet bgs = feet below ground surface.

^{b/} Monitoring wells DW-1 and MW-1 through MW-5 installed October 19-20, 1992.

^{c/} Monitoring well MW-1 not sampled in August 1993 and April 1995 due to the presence of free product.

^{d/} Monitoring well MW-6 installed August 13, 1993.

^{e/} Monitoring wells MW-7 through MW-9 installed April 10, 1995.

^{f/} µg/L = micrograms per liter for all analytes, unless noted otherwise.

^{g/} ... = not analyzed.

^{h/} MTBE = methyl tert-butyl ether.

^{i/} Values for total recoverable petroleum hydrocarbons (TRPH) provided in milligrams per liter.

(MTBE) (45 µg/L), and naphthalene (330 µg/L) during the October 1992 sampling event. Free-phase product (mobile light nonaqueous-phase liquid [LNAPL]) was observed in MW-1 during subsequent groundwater sampling events in August 1993 (1.25 inches) and April 1995 (no measurement available). Petroleum hydrocarbons consistent with a diesel fuel release were not evident in groundwater samples collected from the deep source area well (DW-1) during the October 1992 sampling event; however, vinyl chloride (180 µg/L) and *cis*-1,2-dichloroethene (DCE) (12 µg/L) were detected. Subsequent groundwater sampling at DW-1 has continued to indicate chlorinated volatile organic compound (VOC) contamination, but no petroleum hydrocarbon contamination. No petroleum hydrocarbons have been detected in the perimeter monitoring wells MW-2 through MW-6 since monitoring began in October 1992. Total lead concentrations ranged from 2 to 48 µg/L in the shallow wells, with the maximum concentration detected in MW-5 (Table 2.3). Groundwater samples have not been collected at the site since 1995.

2.3.2 Contamination Assessment Results

The CAR (CH2M Hill, 1994) provided recommendations for mobile LNAPL removal, bioventing treatment of site soils, and groundwater monitoring from all site wells. FDEP (1994) reviewed the CAR and provided comments, which included the need for better delineation of the dissolved petroleum hydrocarbon plume and mobile LNAPL recovery if measurable amounts continued to be detected in site monitoring wells. FDEP did not require a chlorinated solvent investigation as part of the CAR, because the chlorinated VOC contamination evident in groundwater from DW-1 appeared to be related to a large plume originating in the Hangar K Area (Site DP-35), approximately 1,200 feet south of (upgradient from) Facility 1748 (Figure 2.1).

In response to FDEP comments on the original CAR, three additional monitoring wells (MW-7, MW-8, and MW-9) were installed and sampled in April 1995 to better delineate the extent of the petroleum hydrocarbon plume. Groundwater analytical results (Table 2.3) for samples from these three wells indicated that BTEX and TRPH contamination was limited to the immediate vicinity of the original UST (MW-1); however, PAHs, total lead, and chlorinated VOCs were detected in these perimeter monitoring wells. Elevated concentrations of 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, fluorene, and phenanthrene were evident in the sample collected from MW-9, approximately 55 feet northeast of the former UST. An elevated concentration of total lead also was detected at MW-7 (27.9 µg/L) during the April 1995 sampling event. The most prevalent chlorinated VOC, *cis*-1,2-dichloroethene, was detected at 11 µg/L, 3.2 µg/L, and 4.9 µg/L from MW-7, MW-8, and MW-9, respectively. As a result of a June 1995 sampling event at MW-1, which indicated less than 0.1 inch of mobile LNAPL, CH2M Hill (1995) recommended in the CAR Addendum that free-phase product be further addressed in a Remedial Action Plan (RAP) for the site.

2.3.3 Remedial Action Plan

As part of the Air Force Installation Restoration Program (IRP), Parsons ES (1996b) completed a Remedial Action Plan to address contaminated soil and groundwater in the

vicinity of the former diesel UST. The RAP included additional mobile LNAPL investigation results, and concluded that free-phase product no longer exists at the site, based on the June 1995 sampling event. In addition, the RAP confirmed that the vinyl chloride contamination in groundwater was suspected to result from the Hangar K Area and would be addressed as part of the Resource Conservation and Recovery Act (RCRA) Facility Investigations and Corrective Measures Study (RFI/CMS) for that site. The RAP recommended continued operation of the bioventing system to remediate excessively contaminated soils, and implementation of a monitoring-only plan for site groundwater.

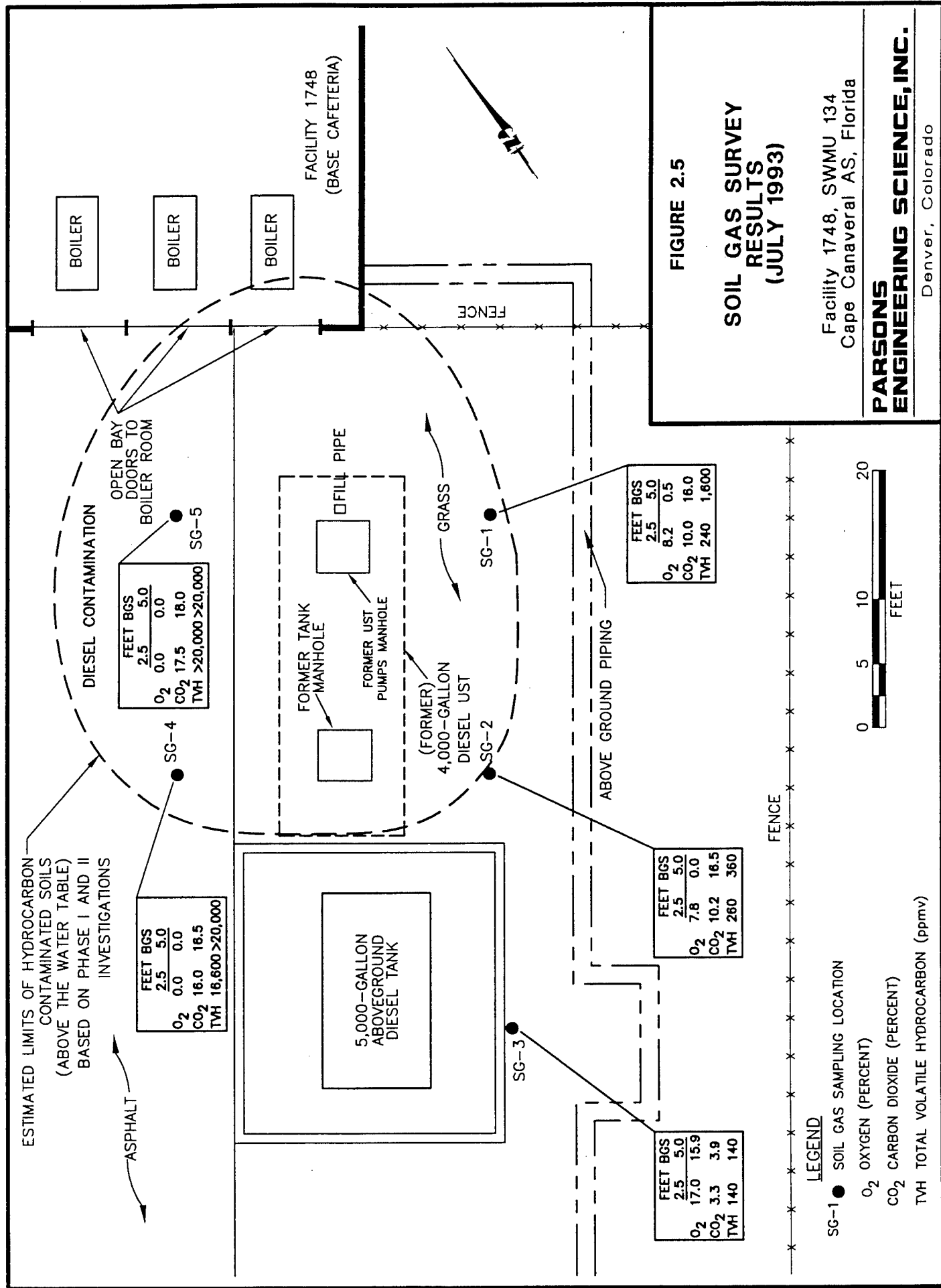
In January 1997, FDEP (1997a) provided comments on the RAP. Approval of the RAP was not given by FDEP because the bioventing portion of the RAP was not certified by a State of Florida-registered Professional Engineer. A RAP addendum was submitted by the Parsons ES - Orlando office to Patrick AFB in April 1998 to address FDEP comments. Following Patrick AFB approval, the RAP addendum will be forwarded to FDEP.

2.4 PILOT-SCALE AND EXTENDED BIOVENTING

As part of the AFCEE Bioventing Initiative, ES (1994) conducted a soil gas survey at Facility 1748 in July 1993 to determine the extent of oxygen depletion in vadose zone soils near the UST. Soil gas samples were collected from five sampling locations at depths of 2.5 and 5 feet bgs, and field-analyzed for oxygen, carbon dioxide, and TVH. The results of the survey are presented on Figure 2.5. Oxygen concentrations measured below 1 percent at the 5-foot depth interval at the four soil gas monitoring points closest to the UST (SG-1 through SG-4), and no oxygen was detected in the 2.5-foot interval at SG-4 and SG-5. Significant TVH concentrations also were detected in soil gas from these locations. Based on these findings, it appeared that aerobic biodegradation of petroleum hydrocarbon contaminants in soils was naturally occurring and would likely be enhanced with a supplemental oxygen supply (i.e., air injection bioventing).

Following removal of the UST in December 1993, ES (1994) installed a pilot-scale bioventing system at Facility 1748 to assess the potential for air injection bioventing to remediate the hydrocarbon contamination identified in vadose zone soils. The primary objectives of the pilot test were: 1) to assess the potential for supplying oxygen throughout the contaminated soil profile; 2) to determine the rate at which indigenous microorganisms would degrade petroleum hydrocarbons when stimulated by oxygen-rich soil gas at this site; and 3) to evaluate the potential for sustaining these rates of biodegradation until hydrocarbon contamination was remediated below regulatory approved standards (ES, 1993).

The pilot test location and system configuration were based on the Phase I and Phase II investigation data (CH2M Hill, 1994) and the soil gas survey performed by ES, which indicated that the highest petroleum hydrocarbon concentrations in vadose zone soils and the lowest oxygen concentrations in soil gas were located within a 20- to 35-foot radius of the former UST. The pilot-scale bioventing system consisted of one vertical air injection VW, three single-depth soil gas monitoring points (MPA, MPB, and MPC), one multi-depth background soil gas monitoring point (MPBG), a

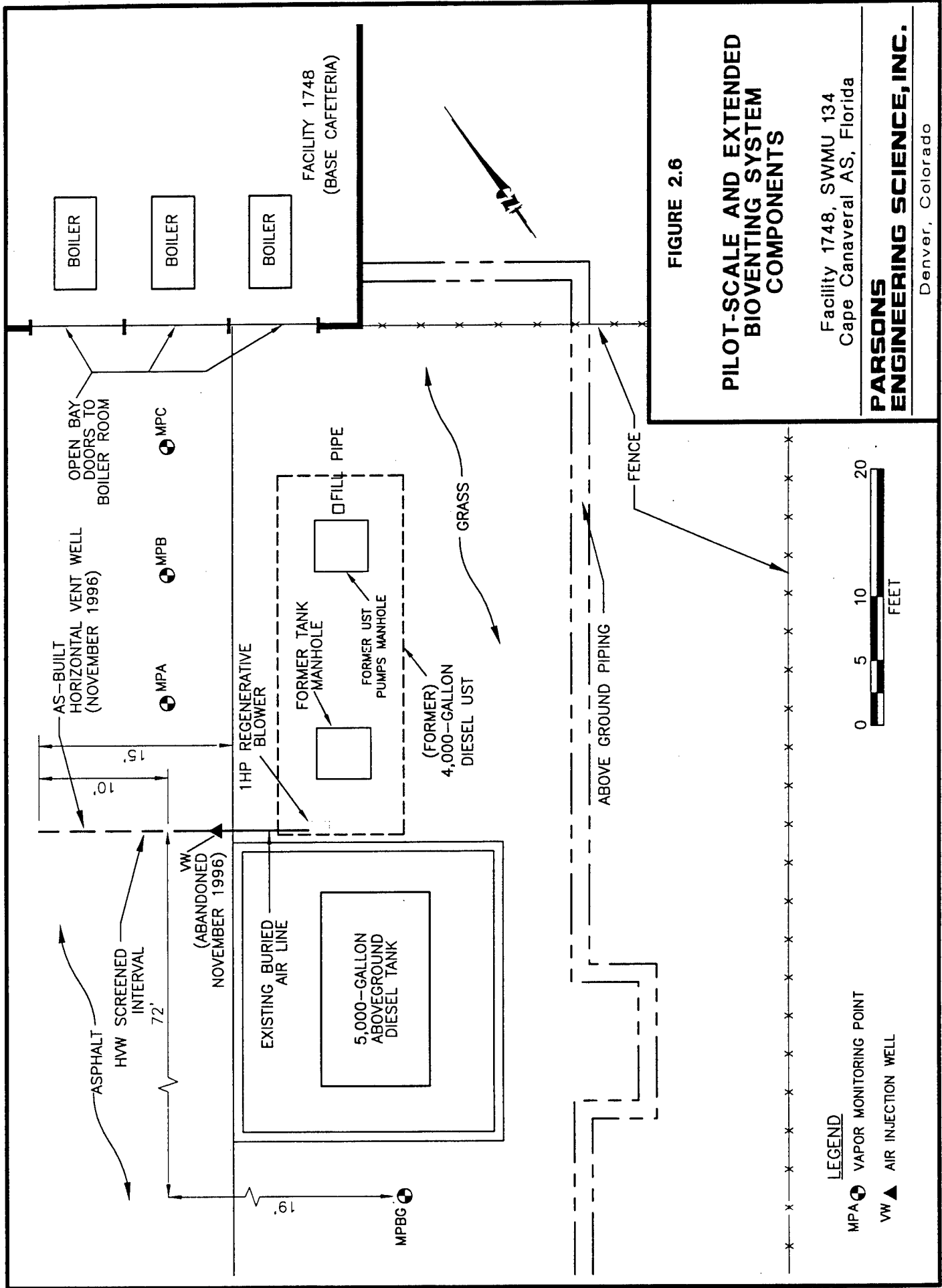


1-horsepower regenerative blower, blower piping and gauges, and a weatherproof blower shed. A layout of the bioventing system is presented in Figure 2.6.

In an attempt to ensure aeration of the vadose zone during seasonal water table fluctuations, the VW was screened from approximately 3 to 8 feet bgs. At the time of system installation, the shallow water table was at approximately 6.5 feet bgs. At MPA, MPB, and MPC, a single screened interval was placed from 5.0 to 5.5 feet bgs. At MPBG, a screened interval was placed from 2.5 to 3.0 feet bgs, and a second screened interval was placed from 5.0 to 5.5 feet bgs. During installation and testing of the pilot-scale system, soil and soil gas sampling, and respiration and soil-to-air permeability testing were performed. Based on results of the oxygen influence and air permeability testing, the long-term radius of oxygen influence around the VW exceeded 30 feet. A detailed description of the pilot-scale bioventing system design and initial testing results are provided in the Draft Interim Pilot Test Results Report (ES, 1994) and also are summarized in the RAP (Parsons ES, 1996b).

Following completion of pilot-scale bioventing system installation and testing, the system was started, optimized, and operated continuously from May 1994 until December 1995. During the 6-month system check, the MP screened intervals were found to be submerged because of elevated water table conditions, and respiration testing was not performed. Elevated water table conditions also prevented respiration testing, and soil and soil gas sampling during the 1-year testing event. Final testing under the AFCEE Initiative project was postponed approximately 6 months to allow the water table to subside. The blower system was turned off 25 days prior to 18-month testing to allow vadose zone soils to return to equilibrium conditions in order to compare initial and 18-month conditions. Soil and soil gas samples were collected, and *in situ* respiration testing was performed in late December 1995. Soil gas sampling and respiration testing was performed only at the VW, because the MP screened intervals located 5.5 feet bgs were flooded. The blower system was restarted following testing to continue bioventing treatment of site soils. Initial and 18-month soil and soil gas sampling and *in situ* respiration testing results were provided by Parsons ES (1996a) to AFCEE. In anticipation that further bioventing operation would be necessary to fully remediate petroleum hydrocarbon contaminated soils, Facility 1748 was included in the AFCEE Extended Bioventing program under which funding was provided for 1-year of extended operation and maintenance followed by soil gas sampling and respiration testing (Option 1), and confirmation/closure sampling (Option 2).

In April 1996, following 2 years of bioventing system operation, the blower system was shut down in preparation for Option 1 soil gas sampling and respiration testing. Blower shutdown occurred approximately 1 month prior to testing to allow soil and soil gas at site to return to equilibrium conditions for comparison of 2-year system monitoring results with previous monitoring results. Option 1 soil gas sampling and respiration testing was performed by Parsons ES from May 29, to June 2, 1996. The 5.5-foot bgs MP screened intervals again were submerged during the 2-year testing event, and consequently, Parsons ES installed new MPs with screened intervals from 2.5 to 3.0 feet bgs in the existing MP well boxes. The 2-year testing event results indicated that soil gas concentrations of TVH and BTEX had been significantly reduced, but microbial respiration and fuel biodegradation rates were only slightly reduced. Because aerobic biodegradation of existing fuel contaminant residuals was



still occurring at significant rates, Option 2 confirmation/closure sampling was postponed. Results of the Option 1 testing event and recommendations for continued system operation were provided in a Parsons ES (1996c) letter results report to AFCEE and Patrick AFB. The blower system was restarted following 2-year testing.

In November 1996 (while installing the expanded-scale bioventing system at Facilities 44625D and 44625E), Parsons ES (1997) replaced the vertical VW at Facility 1748 with a 10-foot-long HVW (The vertical VW remains in place at the site, but is no longer used for air injection). The new HVW was installed approximately 2.5 feet bgs to provide aeration of vadose zone soils during seasonally high water table conditions and ensure year-round oxygenation of the interval contaminated with residual petroleum contaminants. Field measurements collected following installation of the HVW indicated significant improvements in vadose zone oxygenation. A summary of the HVW installation and field measurements was provided by Parsons ES (1997) to AFCEE and Patrick AFB.

2.4.1 Soil Sampling Results

Soil samples were collected during the installation of the pilot-scale bioventing system in December 1993 to determine baseline contaminant concentrations at the VW and MP locations, and again in December 1995, following 18-months of pilot-scale bioventing system treatment. Significantly contaminated soils, identified based on visual appearance, odor, and headspace field screening, were encountered during installation of the VW, MPA, MPB, and MPC. The highest concentrations of VOCs were field measured in soil samples collected between 4 and 6.5 feet bgs (the approximate water table depth during system installation). No soil contamination was evident at the background location (MPBG). During system installation, headspace field screening results for collected soil samples ranged from 140 to greater than 20,000 ppmv. Initial and 18-month soil samples were collected from 5.5 feet bgs at MPA, MPB, and the VW boreholes and were submitted for laboratory analysis of TRPH by US Environmental Protection Agency (USEPA) Method 418.1 and BTEX by USEPA Method SW8020. Initial and 18-month pilot-scale bioventing system soil sample results are presented in Table 2.4.

During the initial 18 months of bioventing system operation, soil TRPH concentrations were reduced at the VW, but similar reductions were not evident at MPA and MPC. Saturated soils near the 5.5-foot sample depth have not benefited appreciably from bioventing because of elevated water table conditions, and significant TRPH concentrations likely persist in these soils. However, the 18-month soil sampling indicated that benzene and toluene concentrations are not significant in site soils, and ethylbenzene and total xylenes concentrations appear to have been reduced between 1 and 2 orders of magnitude.

2.4.2 Soil Gas Sampling Results

Soil gas sampling was performed in January 1994 prior to bioventing system startup (in May 1994), and in December 1995 and May 1996, following approximately 18-months and 2-years of extended system operation, respectively. Field and analytical soil gas results from the first 2 years of bioventing system operation are provided in Table 2.5.

TABLE 2.4
INITIAL AND 18-MONTH SOIL ANALYTICAL RESULTS
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Analyte (Units) ^{a/}	Sample Location-Depth (feet below ground surface)					
	VW-5.5		MPA-5.5		MPB-5.5	
	Initial ^{b/}	18-Month ^{c/}	Initial	18-Month	Initial	18-Month
TRPH (mg/kg)	18,800	6,600	20,200	24,000	12,600	15,000
Benzene (mg/kg)	<0.14 ^{d/}	<0.0025	<2.8	<0.061	<0.54	<0.062
Toluene (mg/kg)	<0.14	<0.0025	<2.8	<0.061	<0.54	<0.062
Ethylbenzene (mg/kg)	0.51	0.0113	5.1	<0.490	<0.54	0.180
Xylenes (mg/kg)	3.7	0.040	8.3	<0.760	5.1	0.390
Moisture (percent)	9.1	18.6	11.8	18.3	6.7	19.4

^{a/} TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

^{b/} Initial soil samples collected on December 30, 1993. Bioventing system operation began in May 1994.

^{c/} 18-Month soil samples collected on December 23, 1995.

^{d/} < = analyte not detected in sample; number shown represents the laboratory method detection limit.

TABLE 2.5
BIOVENTING FIELD AND ANALYTICAL SOIL GAS RESULTS
 FACILITY 1748, SWMU 134
 CAPE CANAVERAL AS, FLORIDA

Sample Location	Sampling Event	Sampling Date	Screen Depth ^{a/}	Field-Screening Data			Laboratory Data ^{d/}				
				Oxygen (percent)	Carbon Dioxide (percent)	TVH ^{b/} (ppmv) ^{c/}	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
VW	Initial	Jan-94	3-WT ^{e/}	0.0	16.5	300	510	0.26	<0.006 ^{f/}	1.2	2.6
	1.5-Year	Dec-95	3-WT	9.0	5.8	340	0.18	<0.002	<0.002	<0.002	<0.002
	2-Year	May-96	3-WT	NA ^{g/}	NA	NA	-- ^{h/}	--	--	--	--
MPA	Initial	Jan-94	5.5	0.0	16.9	360	740	0.91	<0.020	3.6	3.9
	2-Year	May-96	3.0	0.5	11.0	172	0.49	<0.002	<0.002	<0.002	<0.002
MPB	Initial	Jan-94	5.5	0.0	17.5	420	--	--	--	--	--
	2-Year	May-96	3.0	0.0	11.8	200	1.6	0.002	0.006	0.003	0.018
MPC	Initial	Jan-94	5.5	0.0	18.0	500	1,000	3.3	<0.10	5.5	3.4
	2-Year	May-96	3.0	0.0	13.0	196	1.3	<0.002	<0.002	<0.002	<0.002
MPBG	Initial	Jan-94	3.0/5.5	20.5/20.3	0.5/0.7	0.0/0.0	--	--	--	--	--
	2-Year	May-96	3.0	20.0	1.1	80	--	--	--	--	--

^{a/} Screen depth given in feet below ground surface.

^{b/} TVH = total volatile hydrocarbons.

^{c/} ppmv = parts per million, volume per volume.

^{d/} Laboratory analysis of soil gas performed using USEPA Method TO-3.

^{e/} WT = water table. The vent well is screened from 3 to 8 feet bgs; however, the bottom of the effective screened interval was shallower due to elevated water table conditions.

^{f/} < = compound analyzed for, but not detected. Number shown represents the laboratory method detection limit.

^{g/} NA = not available.

^{h/} -- = not sampled.

Soil gas sampling results from 18 months and 2 years following bioventing system startup indicate a 3-order-of-magnitude reduction in TVH and BTEX concentrations (Table 2.5). A soil gas sample could be collected only from the VW during 18-month testing because the MP screened intervals installed at 5.5 feet bgs were flooded. During the 2-year sampling event, the MP screened intervals again were flooded, and soil gas samples were collected from the newly installed screened intervals at 3 feet bgs. Based on these soil gas sample results, bioventing appears to have been effective in reducing TVH and BTEX concentrations in vadose zone soils; however, samples could not be collected at 5.5 feet bgs for direct comparison to initial conditions, and these deeper, sometimes saturated, soils have not benefited from continuous bioventing treatment.

2.4.3 Respiration Test Results

Respiration and fuel biodegradation rates for Facility 1748 are shown in Table 2.6. As previously indicated, elevated water table conditions prevented the evaluation of *in situ* respiration rates at the original MPs (5.5 feet bgs) during 1-year, 18-month, and 2-year testing. However, respiration rates were evaluated at newly installed MPA-3, MPB-3, and MPC-3 during 2-year testing. Based on these results, it appeared that a moderate reduction of *in situ* respiration and microbial biodegradation rates occurred in vadose zone soils during the first 2 years of bioventing, but that petroleum hydrocarbon residuals in site soils would be further reduced with continued bioventing.

2.4.4 Improved System Performance Through HVW Air Injection

Following approximately 2.5 years of air injection into the original vertical VW, the blower system was plumbed to the new HVW installed approximately 2.5 feet bgs. Prior to system startup and following system optimization, soil gas measurements were collected to evaluate oxygen delivery by the HVW. These measurements are provided in Table 2.7. Field measurements of oxygen, carbon dioxide, and TVH following installation and 2 days of air injection into the HVW indicated that the revamped system configuration would improve vadose zone oxygenation and not be subject to reduced air delivery during periods of high water table conditions. The bioventing system at Facility 1748 has been utilizing the HVW air injection configuration since November 1996.

TABLE 2.6
SUMMARY OF RESPIRATION AND FUEL BIODEGRADATION RATES
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Location	Initial (January 1994) ^{a/b/}			18-Month (December 1995) ^{f/}			2-Year (June 1996) ^{g/}		
	Respiration Rate (% O ₂ /hour) ^{c/}	Degradation Rate (mg/kg/year) ^{d/}	Soil Temperature (°C) ^{e/}	Respiration Rate (% O ₂ /hour)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	Respiration Rate (% O ₂ /hour)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
MPA	0.16	640	22.1	-- ^{h/}	--	NS ^{i/}	0.14	280	26.6
MPB	0.15	840	NA ^{j/}	--	--	NA	0.11	180	NA
MPC	0.16	950	23.1	--	--	NS	0.22	350	27.3
VW	NS	NC ^{k/}	NA	0.14	240	NA	NS	NC	NA

^{a/} Initial respiration testing performed in January 1994, but system operation did not begin until May 1994.

^{b/} Initial respiration testing results from the monitoring point screened intervals 5.5 feet below ground surface.

^{c/} % O₂/hour = percent oxygen utilization per hour.

^{d/} mg/kg/year = milligrams of hydrocarbons per kilogram of soil per year.

^{e/} Soil temperatures are from 5.5 feet bgs.

^{f/} Unable to perform respiration testing during 6-month and 1-year site visits; all MP screened intervals (5.5 feet bgs) were flooded due to elevated water table conditions.

^{g/} 2-Year respiration testing results from the 3.0-foot-bgs MP screened intervals which were installed during this site visit.

^{h/} -- = no respiration testing performed; 5.5-foot-bgs MP screened intervals were flooded/below water table.

^{i/} NS = not sampled.

^{j/} NA = not applicable; no temperature probe (thermocouple) at this location.

^{k/} NC = without respiration data, degradation rates cannot be calculated.

TABLE 2.7
HVW AIR INJECTION INFLUENCE
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Location	Distance From HVW (feet)	Screen Depth (feet)	Pressure Response (in. H ₂ O) ^{c/}	Pre-Startup Measurements (11/11/96) ^{a/}			Post-Optimization Measurements (11/13/96) ^{b/}		
				Oxygen (percent)	Carbon Dioxide (percent)	TVH (ppmv) ^{d/}	Oxygen (percent)	Carbon Dioxide (percent)	TVH (ppmv)
MPA	10	3.0	1.2	7.1	6.7	300	21.0	0.1	44
		5.5	1.1	1.0	11.6	440	20.2	0.7	200
MPB	20	3.0	0.6	3.3	9.0	320	20.7	0.5	36
		5.5	0.6	0.0	11.6	400	19.2	1.3	128
MPC	30	3.0	0.2	1.5	11.5	360	20.5	0.5	28
		5.5	0.2	0.0	13.0	660	16.6	3.5	156

^{a/} Measurements taken prior to re-starting system.

^{b/} Measurements taken after approximately 2 days of system operation.

^{c/} in. H₂O = inches of water.

^{d/} ppmv = parts per million, volume per volume. Meter adjusted for full-gas response.

SECTION 3

SOIL AND GROUNDWATER CLEANUP REQUIREMENTS

3.1 SITE CHARACTERIZATION REQUIREMENTS

The objective of the confirmation soil sampling is to support an NFA proposal for soils contaminated by diesel fuel from the former UST at Facility 1748. The objective of the confirmation groundwater sampling is to document the reduction of dissolved petroleum hydrocarbon contamination in site groundwater and evaluate the effectiveness of remediation by natural attenuation. It is anticipated that soil and groundwater analytical results will meet FDEP (1997b) risk-based criteria for NFA, or groundwater monitoring only, and that no further soil remediation will be necessary. This SAP targets unsaturated and smear-zone soils and groundwater in the immediate vicinity of the former diesel fuel UST at Facility 1748.

3.2 CLEANUP CRITERIA

This section describes Florida's closure approach for sites contaminated with petroleum products. The final draft *Petroleum Contamination Site Cleanup Criteria* rule (Chapter 62-770, FAC) (FDEP, 1997b) presents guidance for determination of remedial requirements for closure of petroleum-contaminated sites, including several mechanisms for determining matrix-specific cleanup criteria. The regulations allow closure of petroleum release sites under several different scenarios, including:

- NFA Proposal Without Conditions,
- NFA Proposal With Conditions, or
- Monitoring-Only Proposal for Natural Attenuation.

Closure of a site under the NFA-Without-Conditions alternative would allow unrestricted future use of the site (e.g., residential land use), and therefore the requirements and allowable contaminant levels under this alternative are the most restrictive. The NFA-With-Conditions alternative requires that appropriate institutional or engineering controls be implemented to limit receptor exposure to contaminated media; sites seeking closure under this alternative are subject to potentially less stringent cleanup levels. A natural attenuation monitoring program is a recognized means of remediating sites with petroleum hydrocarbon contamination in groundwater, with the goal of achieving the NFA target cleanup levels.

3.2.1 No Further Action Without Conditions

Closure of a petroleum release site under an NFA Proposal without conditions requires that a site meet the following criteria:

- No mobile LNAPL is present;
- No fire or explosion hazard is present due to release of petroleum or petroleum products ;
- No "excessively contaminated soil" is present; and
- Matrix-specific target cleanup levels (for soil and groundwater) are met.

Contaminant concentrations in all affected media at a site must be below all applicable target cleanup levels for the site to qualify for a NFA without conditions proposal. The *Petroleum Contamination Site Cleanup Criteria* rule (FDEP, 1997b) incorporates matrix-specific target cleanup levels for petroleum constituents in the form of "look-up" tables or through reference to other applicable regulations (i.e., state groundwater or surface water regulations).

To demonstrate that contaminated soil is not present in the unsaturated zone, representative soil samples must show that concentrations of the applicable petroleum products' chemicals of concern are less than FDEP (1997b) direct human exposure and leachability target levels. If leachability target cleanup levels are exceeded, direct leachability testing can be performed to determine if leachate concentrations exceed the applicable groundwater target cleanup levels. In addition, the rule also allows for the development of alternative cleanup standards that can be used in place of those presented in the look-up tables. The alternative cleanup standards must be developed based on site-specific exposure scenarios and risk assessment.

3.2.2 No Further Action With Conditions

Closure of a petroleum release site under an NFA Proposal with conditions requires that a site meet the first three criteria for NFA without conditions (Section 3.2.1); however, alternative target cleanup levels may be justified by the property owner by agreeing to the enactment of institutional controls (i.e., land use restrictions) and/or engineering controls. For soil, less restrictive direct-exposure target cleanup levels may be used and leachability target cleanup levels may be exceeded if it can be demonstrated based on site characteristics and restrictions specified in the institutional control, that petroleum product chemicals of concern will not leach into groundwater at concentrations exceeding applicable groundwater target cleanup levels. For groundwater, alternative groundwater target cleanup levels may be justified depending on the current and projected use of groundwater in the vicinity and by enacting appropriate institutional controls.

3.2.3 Natural Attenuation With Monitoring

The FDEP recognizes natural attenuation with monitoring as a viable site rehabilitation strategy. The following criteria must be met to demonstrate that this strategy is appropriate for a site:

- No mobile LNAPL is present;
- Contaminated soil is not present or does not constitute a continuing source of contamination to groundwater;
- Groundwater contaminant concentrations above applicable target cleanup levels are not migrating beyond a temporary point of compliance (POC);
- Available data show an overall decrease in the mass of contamination; and
- Contaminant concentrations in groundwater do not exceed appropriate criteria (Table IX levels, 62-770, FAC); or technical evaluations (as specified in 62-770.690 (1)(f), FAC) indicate that natural attenuation is an appropriate remedial alternative.

Natural attenuation with monitoring requires the establishment of a temporary POC based on site-specific conditions relating to land and groundwater use, potentially exposed populations, hydrogeology, and type and concentrations of contaminants. If human health, public safety, and the environment are protected, the POC may be moved to the property boundary, or beyond the property boundary (with notice), if necessary to address current plume conditions.

3.3 CLEANUP STANDARDS FOR FACILITY 1748, SWMU 134

Based on soil gas sampling and respiration testing results following almost 4 years of air injection bioventing, it is anticipated that the released diesel fuel chemicals of potential concern (COPCs) in unsaturated and smear zone soils near the former UST at Facility 1748 are less than the applicable FDEP target cleanup levels for NFA. In addition, diesel fuel COPCs in groundwater resulting from the former UST also are likely to meet FDEP criteria for NFA, or natural attenuation with monitoring. However, other site contaminants in groundwater (e.g., DCE and vinyl chloride) originating from the Hangar K area may have to be addressed, and institutional or engineering controls may be necessary.

3.3.1 Soil Criteria

Confirmation soil sample results will be compared to target cleanup levels established by FDEP to demonstrate that petroleum hydrocarbon contaminants in site soils have been sufficiently remediated to meet the requirements for a NFA proposal. Specifically, direct-exposure and leachability target cleanup levels from Table IV (FDEP, 1997b) will be used as the initial cleanup criteria. Confirmation soil sampling results will be compared to the residential and industrial direct-exposure levels and leachability target levels for groundwater resource protection and recovery (because

shallow groundwater at the site is not likely to impact surface water in the vicinity of Cape Canaveral AS).

Table 3.1 compares the maximum detected site soil concentrations of petroleum hydrocarbon contaminants to the proposed FDEP target cleanup levels. As is evident from this comparison, pre-bioventing concentrations of BTEX and TRPH in soil were not in compliance with FDEP (1997b) direct-exposure or leachability target cleanup levels. However, it is anticipated that representative confirmation soil sampling results will demonstrate that BTEX and PAH concentrations in soil are below the prescribed levels. Based on the significant concentrations TRPH previously detected in site soils, elevated TRPH concentrations may still remain in site soils, and the development of an alternative cleanup level for this contaminant class may be necessary.

3.3.2 Groundwater Criteria

Similarly, confirmation groundwater sampling results will be compared to target cleanup levels established by FDEP to demonstrate that petroleum hydrocarbon contaminants in groundwater have been sufficiently reduced by bioventing treatment of source area soils and natural attenuation to meet the requirements for an NFA, or monitoring only, proposal. Groundwater contaminant concentrations will be compared to FDEP (1997b) target cleanup levels for groundwater resource protection and recovery (Table V) and natural attenuation source default concentrations (Table IX).

Table 3.2 presents a comparison of previous groundwater analytical results with the proposed FDEP (1997b) criteria. Based on this comparison, groundwater at the site is likely to meet the natural attenuation default criteria and the groundwater protection criteria at all but the shallow source area well (MW-1).

3.3.3 Alternative Cleanup Standards

For those contaminants exceeding target cleanup levels for NFA (With or Without Conditions), alternative cleanup standards for soil and/or groundwater contaminated with petroleum products may be developed based on a site-specific risk assessment. Development of alternative standards for those chemicals that are below the more stringent levels provided in the Rule should not be necessary.

If performed, the risk assessment would include a site-specific exposure assessment based on:

- Chemical concentrations in all contaminated media;
- Soil properties;
- Potential exposure pathways and routes;

TABLE 3.1
COMPARISON OF MAXIMUM SITE SOIL CONCENTRATIONS
TO TARGET CLEANUP LEVELS
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Chemical Name	Units	Maximum Concentration Detected	Location of Maximum Detection	Sample Collection Date	FDEP Target Cleanup Levels ^a		
					Direct-Exposure ^b		Soil Leachability ^c
					I	II	
TRPH ^{d/}	mg/kg ^{e/}	24,000	MPA-5.5	Dec-95	350	2,500	340
Benzene	mg/kg	<2.8 ^{f/}	MPA-5.5	Dec-93	1.1	1.50	0.007
Ethylbenzene	mg/kg	5.1	MPA-5.5	Dec-93	240	240	0.4
Toluene	mg/kg	<2.8	MPA-5.5	Dec-93	300	2,000	0.4
Xylenes	mg/kg	8.3	MPA-5.5	Dec-93	290	290	0.3
Acenaphthene	mg/kg	NR ^{g/}	NA ^{h/}	NA	2,300	22,000	4
Acenaphthylene	mg/kg	NR	NA	NA	1,100	11,000	22
Anthracene	mg/kg	NR	NA	NA	19,000	290,000	2,000
Benzo(a)anthracene	mg/kg	NR	NA	NA	1.4	5.1	2.9
Benzo(a)pyrene	mg/kg	NR	NA	NA	0.1	0.5	7.8
Benzo(b)fluoranthene	mg/kg	NR	NA	NA	1.4	5	9.8
Benzo (g,h,i)perylene	mg/kg	NR	NA	NA	2,300	45,000	13,000
Benzo(k)fluoranthene	mg/kg	NR	NA	NA	15	52	25
Chrysene	mg/kg	NR	NA	NA	140	490	80
Dibenzo(a,h)anthracene	mg/kg	NR	NA	NA	0.1	0.5	14
Fluoranthene	mg/kg	NR	NA	NA	2,800	45,000	550
Fluorene	mg/kg	NR	NA	NA	2,100	24,000	87
Indeno(1,2,3-cd)pyrene	mg/kg	NR	NA	NA	1.5	5.2	28
Naphthalene	mg/kg	NR	NA	NA	1,000	8,600	1
Phenanthrene	mg/kg	NR	NA	NA	1,900	29,000	120
Pyrene	mg/kg	NR	NA	NA	2,200	40,000	570

Notes: Shading indicates maximum site concentration above target cleanup level indicated.

a/ FDEP, 1997b.

b/ Direct Exposure I and II are for No Further Action Without or With Conditions, respectively.

c/ Based on Table V (Groundwater Cleanup Target Levels).

d/ TRPH = total recoverable petroleum hydrocarbons. Maximum concentration based on analysis by USEPA Method 418.1. Target cleanup levels based on State of Florida FL-PRO analysis.

e/ mg/kg = milligrams per kilogram.

f/ < = less than the laboratory reporting limit shown.

g/ NR = no results available.

h/ NA = not applicable.

TABLE 3.2
COMPARISON OF MAXIMUM SITE GROUNDWATER CONCENTRATIONS
TO TARGET CLEANUP LEVELS
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Chemical Name	Units	Maximum Concentration Detected	Location of Maximum Detection	Sample Collection Date ^{b/}	FDEP Target Cleanup Levels ^a	
					Table V Target Cleanup Level ^{c/}	Table IX Natural Attenuation Source Default ^d
TRPH ^{e/}	mg/L ^{f/}	40.5	MW-1	Oct-92	5	50
Benzene	µg/L ^{g/}	73	MW-1	Oct-92	1	100
Ethylbenzene	µg/L	110	MW-1	Oct-92	30	300
Toluene	µg/L	< 10 ^{h/}	MW-1	Oct-92	40	400
Xylenes	µg/L	120	MW-1	Oct-92	20	200
Acenaphthene	µg/L	10	MW-9	Apr-95	20	200
Acenaphthylene	µg/L	5.6	MW-9	Apr-95	210	2,100
Anthracene	µg/L	ND ^{i/}	NA ^{j/}	Apr-95	2,100	21,000
Benzo(a)anthracene	µg/L	ND	NA	Apr-95	0.2	20
Benzo(a)pyrene	µg/L	ND	NA	Apr-95	0.2	20
Benzo(b)fluoranthene	µg/L	ND	NA	Apr-95	0.2	20
Benzo (g,h,i)perylene	µg/L	ND	NA	Apr-95	210	2,100
Benzo(k)fluoranthene	µg/L	ND	NA	Apr-95	0.5	50
Chrysene	µg/L	ND	NA	Apr-95	5	500
Dibenzo(a,h)anthracene	µg/L	ND	NA	Apr-95	0.2	20
Fluoranthene	µg/L	ND	NA	Apr-95	280	2,800
Fluorene	µg/L	8.5	MW-9	Apr-95	280	2,800
Indeno(1,2,3-cd)pyrene	µg/L	ND	NA	Apr-95	0.2	20
Naphthalene	µg/L	330	MW-1	Oct-92	20	200
Phenanthrene	µg/L	66	MW-1	Oct-92	210	2,100
Pyrene	µg/L	ND	NA	Apr-95	210	2,100
2-Methylnaphthalene	µg/L	340	MW-1	Oct-92	None	None
1-Methylnaphthalene	µg/L	240	MW-1	Oct-92	None	None

Notes: Shading indicates maximum site concentration is above target cleanup level indicated.

a/ FDEP, 1997b.

b/ Represents the most recent available sample collection date at this location. Free product present in MW-1 during August 1993 and April 1995 sampling events.

c/ Cleanup level for No Further Action With or Without Conditions (FDEP, 1997).

d/ Allowable maximum concentration for remediation by natural attenuation with monitoring.

e/ TRPH = total recoverable petroleum hydrocarbons.

f/ mg/L = milligrams per liter.

g/ µg/L = micrograms per liter.

h/ < = less than the laboratory reporting limit shown.

i/ ND = not detected and sample reporting limit not available.

j/ NA = not applicable.

- Current or potential future exposed populations;
- Exposure factors (i.e., exposure duration and frequency); and
- Expected contaminant concentrations to which actual or potential receptors may be exposed.

In establishing alternative target cleanup levels, the following factors would be used, as appropriate:

- Calculations using a lifetime cancer risk level of 1.0×10^{-6} for carcinogenic COPCs;
- A hazard index of 1 or less for noncarcinogenic COPCs;
- Best achievable detection limits;
- Naturally occurring background concentrations (for inorganics); and/or
- Nuisance, organoleptic, or aesthetic considerations.

These alternative site-specific target cleanup levels, if developed, would be used for closure under an NFA With Conditions proposal.

SECTION 4

SITE CONFIRMATION SOIL AND GROUNDWATER SAMPLING AND ANALYSIS PLAN

The following SAP describes the borehole locations, sampling depths, soil sampling procedures, and analytical methods proposed to collect sufficient data to verify remediation of petroleum hydrocarbon contaminants in vadose and smear zone soils at Facility 1748 to proposed cleanup levels (Table 3.1). Groundwater sampling for petroleum contaminants and various geochemical parameters also is included in the SAP in order to document the nature and extent of dissolved contamination, and the applicability of remediation by natural attenuation with monitoring for the dissolved petroleum hydrocarbon contaminants in site groundwater.

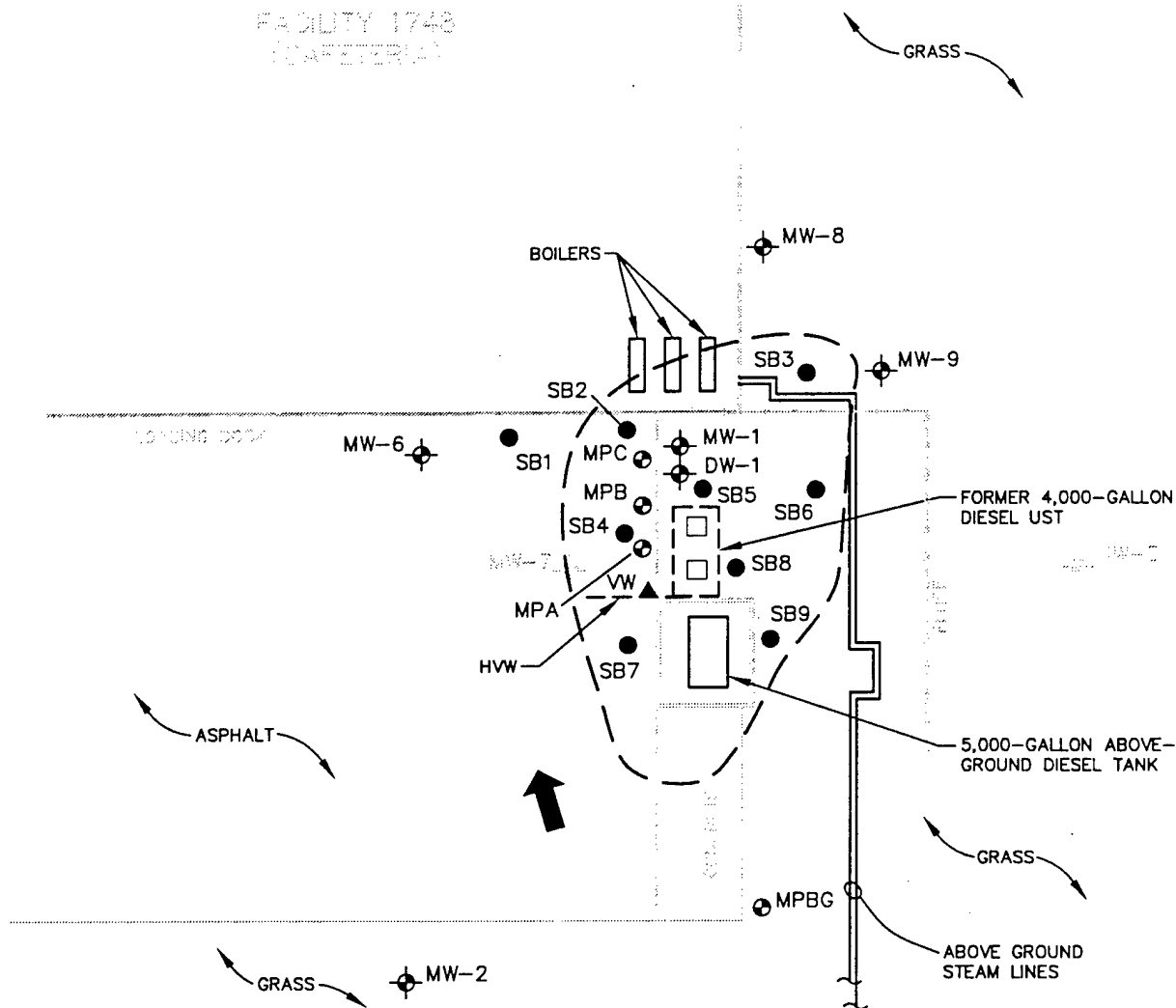
4.1 SOIL SAMPLING

This section describes the scope of work required for collecting confirmation soil samples at Facility 1748. An estimated nine boreholes will be drilled and sampled in the vicinity of the former UST in the area previously shown to contain elevated hydrocarbon concentrations in saturated and unsaturated zone soils (Figure 2.4). A maximum of two additional boreholes may be drilled and sampled if field screening results indicate significant contamination extending beyond the proposed sampling area. Proposed borehole locations are shown on Figure 4.1.

One month prior to soil sampling, the bioventing system at Facility 1748 will be shut down to allow soil and soil gas to return to equilibrium conditions. Soil sampling will be conducted by qualified Parsons ES scientists and technicians trained in the conduct of soil sampling, records documentation, and environmental sample chain-of-custody procedures. In order to provide complete documentation of the sampling event, detailed records will be maintained by the Parsons ES field hydrogeologist. In addition, sampling personnel will have thoroughly reviewed this SAP prior to sample collection and will have a copy available onsite for reference.

4.1.1 Drilling, Sampling, and Equipment Decontamination

Soil boreholes will be advanced to the groundwater table surface (approximately 4 to 6 feet bgs) with a hand auger. Undisturbed soil samples, suitable for chemical analysis, will be obtained from each borehole by collecting the required volume of soil directly from the hand-auger bucket. Soil types will be classified according to the Unified Soil Classification System (USCS) and described in accordance with the standard Parsons ES soil description format. All soil samples will be visually examined, and sample headspace will be field screened for VOCs using a photoionization detector (PID) or a



LEGEND

- MW-1 GROUNDWATER MONITORING WELL TO BE SAMPLED
- SB1 PROPOSED SOIL BOREHOLE
- MPA VAPOR MONITORING POINT
- VW VERTICAL AIR INJECTION VENT WELL
- HVW HORIZONTAL AIR INJECTION VENT WELL
- 1992 ESTIMATED EXTENT OF TOTAL VOLATILE HYDROCARBON CONTAMINATION EXCEEDING 100 ppmv IN SATURATED AND UNSATURATED SOILS
- GROUNDWATER FLOW DIRECTION

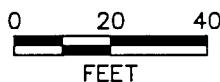


FIGURE 4.1

PROPOSED CONFIRMATION SOIL AND GROUNDWATER SAMPLING LOCATIONS

Facility 1748, SWMU 134
Cape Canaveral AS, Florida

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

TVH analyzer (TVHA). The data obtained from the logging and screening will be recorded on borehole logs.

Based on field screening results, one sample with the greatest apparent petroleum hydrocarbon contamination from each boring will be selected and submitted for laboratory analysis using laboratory-prepared containers. Samples selected for laboratory analysis will be labeled with the site name and borehole number, sample depth, date of collection, project name, and other pertinent data. The sample containers will be sealed in plastic bags and immediately placed in an insulated cooler containing ice. The soil samples will be maintained in a chilled condition until delivered to the analytical laboratory. Chain-of-custody records will be prepared in the field and will accompany the samples to the analytical laboratory.

Augers and other downhole equipment will be cleaned before use and between boreholes to prevent cross-contamination. Between sampling events, the hand-auger bucket will be cleaned with Alconox® detergent, followed by successive potable and distilled water rinses. Drill cuttings will be returned to their respective borehole following drilling and sampling and will be abandoned using bentonite, as necessary. Boreholes drilled through asphalt will be repaired at the surface using asphalt cold-patch.

4.1.2 Soil Sample Analyses

Proposed soil sample analytical methods, estimated number of samples, and reporting limits are presented in Table 4.1. All samples will be analyzed by a State of Florida-certified and AFCEE-approved laboratory. Parsons ES proposes to analyze samples from Facility 1748 for TRPH by State of Florida Method FL-PRO; for BTEX by USEPA Method SW8020; and for PAHs using USEPA Method SW8310. Quality control (QC) samples also will be analyzed to assess laboratory methods. The laboratory will perform analyses on one matrix spike, one laboratory control sample, and one laboratory blank for each specific analytical method requested. Field QC samples will be collected and analyzed as described in Section 4.4.

4.2 GROUNDWATER SAMPLING

This section describes the scope of work required for collecting groundwater samples at existing site groundwater monitoring wells for both field and laboratory analysis. Samples from six existing wells (MW-1, DW-1, MW-2, MW-6, MW-8, and MW-9) will be collected and sent to the laboratory for analyses of various petroleum contaminants. Samples from these six wells also will be analyzed in the field for electron acceptors and other geochemical parameters to assess the degree of natural attenuation of organic contaminants occurring in groundwater at the site. Lastly, samples from two wells, one in the source area (MW-1) and one upgradient (MW-2), will be collected for laboratory methane analysis. The proposed groundwater sampling locations are shown on Figure 4.1, and the groundwater analyses to be performed are listed in Table 4.2.

TABLE 4.1
PROPOSED SOIL SAMPLE ANALYTICAL METHODS,
REPORTING LIMITS, AND NUMBER OF SAMPLES
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Analytical Method	Number of Samples ^a	Reporting Limit ^b	Units ^c	Field or Fixed-Base Laboratory
State of Florida FL-PRO TRPH ^d	9	TBD ^e	mg/kg	Fixed-base
USEPA Method SW8020				
Benzene	9	1.0	µg/kg	Fixed-base
Toluene	9	2.0	µg/kg	Fixed-base
Ethylbenzene	9	2.0	µg/kg	Fixed-base
Xylenes	9	2.0	µg/kg	Fixed-base
USEPA Method SW8310				
Acenaphthene	9	1,200	µg/kg	Fixed-base
Acenaphthylene	9	1,540	µg/kg	Fixed-base
Anthracene	9	440	µg/kg	Fixed-base
Benzo(a)anthracene	9	9	µg/kg	Fixed-base
Benzo(a)pyrene	9	15	µg/kg	Fixed-base
Benzo(a)fluoranthene	9	12	µg/kg	Fixed-base
Benzo(g,h,i)perylene	9	50	µg/kg	Fixed-base
Benzo(k)fluoranthene	9	11	µg/kg	Fixed-base
Chrysene	9	100	µg/kg	Fixed-base
Dibenzo(a,h)anthracene	9	20	µg/kg	Fixed-base
Fluoranthene	9	140	µg/kg	Fixed-base
Fluorene	9	140	µg/kg	Fixed-base
Indeno(1,2,3-cd)pyrene	9	30	µg/kg	Fixed-base
Naphthalene	9	1,200	µg/kg	Fixed-base
Phenanthrene	9	420	µg/kg	Fixed-base
Pyrene	9	180	µg/kg	Fixed-base

^a Excludes QC samples. If optional boreholes are required, one additional soil sample per optional borehole also will be collected and analyzed.

^b Project reporting limit as specified in subcontract for analytical services.

^c mg/kg = milligrams per kilogram; µg/kg = micrograms per kilogram.

^d TRPH = total recoverable petroleum hydrocarbons.

^e TBD = to be determined; reporting limit will be less than criterion listed in Table 3.1.

TABLE 4.2
PROPOSED GROUNDWATER SAMPLE ANALYTICAL METHODS,
REPORTING LIMITS, AND NUMBER OF SAMPLES
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Analytical Method	Number of Samples ^{a/}	Reporting Limit ^{b/}	Units ^{c/}	Field or Fixed-Base Laboratory
State of Florida FL-PRO TRPH ^{d/}	6	TBD ^{e/}	mg/L	Fixed-base
USEPA Method SW8020				
Benzene	6	2	µg/L	Fixed-base
Toluene	6	2	µg/L	Fixed-base
Ethylbenzene	6	2	µg/L	Fixed-base
Xylenes	6	2	µg/L	Fixed-base
USEPA Method SW8310				
Acenaphthene	6	18	µg/L	Fixed-base
Acenaphthylene	6	23	µg/L	Fixed-base
Anthracene	6	6.6	µg/L	Fixed-base
Benzo(a)anthracene	6	0.2 ^{f/}	µg/L	Fixed-base
Benzo(a)pyrene	6	0.2 ^{f/}	µg/L	Fixed-base
Benzo(b)fluoranthene	6	0.18	µg/L	Fixed-base
Benzo(g,h,i)perylene	6	0.76	µg/L	Fixed-base
Benzo(k)fluoranthene	6	0.17	µg/L	Fixed-base
Chrysene	6	5 ^{f/}	µg/L	Fixed-base
Dibenzo(a,h)anthracene	6	0.3	µg/L	Fixed-base
Fluoranthene	6	2.1	µg/L	Fixed-base
Fluorene	6	2.1	µg/L	Fixed-base
Indeno(1,2,3-cd)pyrene	6	0.2 ^{f/}	µg/L	Fixed-base
Naphthalene	6	18	µg/L	Fixed-base
Phenanthrene	6	6.4	µg/L	Fixed-base
Pyrene	6	2.7	µg/L	Fixed-base
USEPA SW9056				
Sulfate	6	0.2	mg/L	Fixed-base
RSKSOP 175 ^{g/}				
Methane	2	NA	NA	Fixed-base

TABLE 4.2 (Continued)
PROPOSED GROUNDWATER SAMPLE ANALYTICAL METHODS,
REPORTING LIMITS, AND NUMBER OF SAMPLES
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Analytical Method	Number of Samples ^{a/}	Reporting Limit ^{b/}	Units ^{c/}	Field or Fixed-Base Laboratory
Hach Method 8000 Series ^{h/}				
Nitrate	6	---	mg/L	Field
Nitrite	6	---	mg/L	Field
Sulfide	6	---	mg/L	Field
Ferrous Iron	6	---	mg/L	Field
Manganese	6	---	mg/L	Field
Direct Reading Meter				
pH	6	---	standard units	Field
Conductivity	6	---	μS/cm	Field
Temperature	6	---	°C	Field
Dissolved Oxygen	6	---	mg/L	Field
Redox Potential	6	---	mV	Field

^{a/} Excludes QC samples.

^{b/} Project reporting limit as specified in subcontract for analytical services.

^{c/} μg/L = micrograms per liter; mg/L = milligrams per liter; μS/cm = microsiemens per centimeter; °C = degrees Celsius; mV = millivolts.

^{d/} TRPH = total recoverable petroleum hydrocarbons.

^{e/} TBD = to be determined; reporting limit will be less than criterion shown on Table 3.2.

^{f/} Number shown represents proposed FDEP (1997b) target cleanup level for groundwater. Laboratory reporting limits for these and all other analytes will be less than criteria listed in Table 3.2.

^{g/} National Risk Management Research Laboratory (formerly Robert S. Kerr Research Laboratory) Standard Operating Procedure for methane or equivalent.

^{h/} "Hach" refers to methods described in the Hach Company catalog, 1990.

Groundwater sampling will be conducted by qualified Parsons ES scientists and technicians trained in the conduct of well sampling. Groundwater sampling will be performed in accordance with the procedures outlined in this SAP.

4.2.1 Well Purging, Sample Collection, and Decontamination

This subsection describes the scope of work required for collecting groundwater samples at each of six existing groundwater monitoring wells. All water samples collected from groundwater monitoring wells will be obtained using either disposable bailers, decontaminated Teflon® bailers, or a thoroughly decontaminated peristaltic pump. In order to maintain a high degree of QC during this sampling event, the procedures described in the following sections will be followed.

4.2.1.1 Equipment Decontamination

All portions of sampling and test equipment that will contact the sample will be thoroughly cleaned before each use. This equipment includes the peristaltic pump and tubing, Teflon® bailers, water-level probe and cable, oil/water interface probe and cable, lifting line, test equipment for onsite use, and other equipment or portions thereof which will contact the samples. Based on the types of sample analyses to be conducted, the following decontamination protocol will be used:

- Clean with potable water and phosphate-free laboratory detergent;
- Rinse with potable water;
- Triple rinse with distilled or deionized water;
- Air dry the equipment prior to use.

If precleaned, dedicated sampling equipment is used, the decontamination protocol specified above will not be required. Laboratory-supplied sample containers will be cleaned and sealed by the laboratory. Sampling and test equipment decontamination and rinsewater will be collected for proper disposal in accordance with procedures described in Section 4.5.

4.2.1.2 Well Purging

Prior to removing any water from the well to be sampled, the static water level will be measured. An electrical water level probe will be used to measure the depth to groundwater below the datum to the nearest 0.01 foot. After measuring the static water level, the water level probe will be lowered slowly to the bottom of the well, and the total well depth will be measured to the nearest 0.01 foot. Based on these measurements, the volume of water to be purged from the well can be calculated. The volume of water contained within the well casing at the time of sampling will be calculated, and either three times the calculated volume will be removed from the well or until field measurements of pH, temperature, and specific conductivity of the purge water become stable. The pH, temperature, and specific conductivity will be monitored before, during, and after well purging and recorded on well sampling forms. Purge

water will be collected for proper disposal in accordance with procedures described in Section 4.5.

An oil/water interface probe will be used at MW-1 to determine if any free-phase product is present. If free-phase product is present at MW-1, the product thickness will be measured and a groundwater sample will not be collected.

4.2.1.3 Sample Extraction

Disposable, polyethylene bailers, reusable Teflon® bailers, or a thoroughly decontaminated peristaltic pump will be used to extract groundwater samples from the wells. The extraction equipment will be lowered into the water gently to prevent splashing and extracted gently to prevent creation of excessive vacuum in the well. The sample will be discharged directly into the appropriate sample container. The water sample will be transferred from the bottom of the bailer using a bottom-emptying device to allow a controlled flow into the sample container. Water from the peristaltic pump can be directly discharged into the sample container. The water will be carefully poured down the inner walls of the sample bottle to minimize aeration of the sample. Unless other instructions are given by the analytical laboratory, sample containers will be completely filled so that no air space remains in the container.

4.2.2 Onsite Chemical Parameter Measurement

Many of the groundwater chemical parameters will be measured onsite by Parsons ES personnel (Table 4.2). Some of the measurements will be made using direct-reading meters, while others will be made using a Hach® portable colorimeter in accordance with specific Hach® analytical procedures. These procedures are described in the following subsections.

All glassware or plasticware used in the analyses will have been cleaned prior to sample collection by thoroughly washing with a solution of Alconox® and water, and rinsing with deionized water and ethanol to prevent interference or cross contamination between measurements. If concentrations of an analyte are above the range detectable by the titrimetric method, the analysis will be repeated by diluting the groundwater sample with double-distilled water until the analyte concentration falls to a level within the range of the method. Sample reagents to be used for field analysis are composed of innocuous salts, and only a few grams of the reagents will be required. All rinseate and sample reagents accumulated during field groundwater analysis will be accumulated with purge waters for proper disposal in accordance with procedures described in Section 4.5.

4.2.2.1 Dissolved Oxygen Measurements

Dissolved oxygen (DO) can be an important electron acceptor in the aerobic biodegradation of dissolved fuel hydrocarbons. DO measurements will be made using a meter with a downhole oxygen sensor or a sensor in a flow-through cell. Measurements will be taken before and following groundwater sample acquisition. When DO measurements are taken in monitoring wells that have not yet been sampled.

the existing monitoring wells will be purged until DO levels stabilize. Measured values will be recorded in the groundwater sampling record.

4.2.2.2 pH, Temperature, and Specific Conductance

Because the pH, temperature, and specific conductance of a groundwater sample can change significantly within a short time following sample acquisition, these parameters will be measured in the field in unfiltered, unpreserved, "fresh" water collected by the same technique as the samples taken for laboratory analyses. The measurements will be made in a clean glass container separate from those intended for laboratory analysis, and the measured values will be recorded in the groundwater sampling record.

4.2.2.3 Other Electron Acceptor Measurements

Nitrate, nitrite, manganese, sulfate, and ferric iron concentrations in groundwater act as potential electron acceptors for fuel hydrocarbon degradation under anaerobic conditions. These analytes, or their reduced byproducts (e.g., ferrous iron and sulfide) will be measured by experienced Parsons ES scientists via colorimetric analysis using a Hach® portable colorimeter according to the appropriate Hach® methods (Table 4.2).

4.2.2.4 Reduction/Oxidation Potential

The reduction/oxidation (redox) potential of groundwater is an indicator of the relative tendency of a solution to accept or transfer electrons. Redox reactions in groundwater often are biologically mediated; therefore, the redox potential of a groundwater system depends upon and influences rates of biodegradation. Redox potentials can be used to provide real-time data on the location of the contaminant plume, especially in areas undergoing anaerobic biodegradation. The redox potential of a groundwater sample can change significantly within a short time following sample acquisition and exposure to atmospheric oxygen. Therefore, this parameter will be measured in the field in unfiltered, unpreserved, "fresh" water collected by the same technique as the samples taken for laboratory analyses. The measurements will be made as quickly as possible in a clean glass container separate from those intended for laboratory analysis.

4.2.3 Sample Handling

Sample containers and appropriate container lids for fixed-base laboratory analysis will be provided by the laboratory. The laboratory will add any necessary chemical preservatives prior to shipping the containers to the site. The sample containers will be filled as described in Section 4.2.1.3, and the container lids will be tightly closed. The sample bottles will be labeled with the site name and well number, sample depth, date of collection, project name, and other pertinent data. Samples will be properly prepared for transportation to the laboratory by placing the samples in a cooler containing ice to maintain a shipping temperature of approximately 4 degrees centigrade (°C). Chain-of-custody records will be prepared in the field and will accompany the samples to the analytical laboratory.

4.2.4 Groundwater Analyses

Proposed groundwater sample analytical methods and laboratory reporting limits are presented in Table 4.2. All samples will be analyzed by a State of Florida-certified and AFCEE-approved laboratory. Parsons ES proposes to analyze groundwater samples from Facility 1748 for TRPH by State of Florida Method FL-PRO; for BTEX by USEPA Method SW8020; for PAHs using USEPA Method SW8310; for sulfate using USEPA Method SW9056; and for methane by Robert S. Kerr Standard Operating Procedure (RSKSOP) 175 or equivalent. QC samples also will be analyzed to assess laboratory methods. The laboratory will perform analyses on one matrix spike, one laboratory control sample, and one laboratory blank for each specific analysis requested. Field QC samples will be collected and analyzed as described in Section 4.4.

4.3 CHAIN-OF-CUSTODY CONTROL

After the samples for laboratory analysis have been collected, chain-of-custody procedures will be followed to establish a written record of sample handling and movement between the sampling site and the laboratory. Samples collected for onsite field analyses will not require chain-of-custody records. Each shipping container will have a chain-of-custody form completed in triplicate by the sampling personnel. One copy of this form will be kept by the sampling contractor after sample delivery to the analytical laboratory, and the other two copies will be submitted to the laboratory with the samples. One of the laboratory copies will become a part of the permanent record for the sample and will be returned to Parsons ES with the sample analytical results. The chain-of-custody will contain the following information:

- Site name and address;
- Sample identification number;
- Sample collector's printed name and signature;
- Date and time of collection;
- Place and address of collection;
- Type of sample (i.e. composite, grab, etc.);
- Sample matrix (soil or groundwater);
- Chemical preservatives added;
- Analytical laboratory to be utilized;
- Analyses requested;
- Signatures of individuals involved in the chain of possession; and
- Inclusive dates of possession.

The chain-of-custody documentation will be placed inside the shipping container so that it will be immediately apparent to the laboratory personnel receiving the container, but will not be damaged or lost during transport. The shipping container will be sealed so that it will be obvious if the seal has been tampered with or broken.

4.4 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Samples must be collected, preserved, transported, and analyzed in such a manner that sampling results yield information that provides a reliable representation of the soil and groundwater quality at the site. To meet this requirement, the procedures described in Sections 4.1 and 4.2 will be followed during sample collection, handling, and analysis. In addition, laboratory QC samples will be analyzed as described in Sections 4.1.2 and 4.2.4.

Field quality assurance for groundwater and soil will include collection of field replicates/duplicates, rinseate blanks, and trip blanks. Groundwater QA/QC sampling will include one duplicate sample (minimum frequency of 10 percent), one rinseate blank, and one trip blank for each cooler with samples designated for VOC analysis. Soil QC sampling will include two replicates (minimum frequency of 10 percent), one rinseate blank, and one trip blank for each cooler with samples designated for VOC analysis.

4.5 MANAGEMENT OF INVESTIGATION-DERIVED WASTES

Soil cuttings generated during hand auger soil sampling will be minimal. Residual cuttings not prepared for laboratory analysis will be returned to their respective soil borehole prior to plugging the borehole with bentonite. Well purge water, Hach® reagent water, and equipment decontamination and rinseate water will be accumulated, transferred to a truck-mounted tank, and transported to the Trident STP (an industrial wastewater treatment plant) at Cape Canaveral AS for discharge and treatment. The site name, source location, volume, date of collection, and other pertinent information will be recorded in the Cape Canaveral AS investigation-derived waste inventory maintained by Parsons ES.

SECTION 5

SITE CONFIRMATION SAMPLING REPORT FORMAT

Following receipt and evaluation of the laboratory analytical results, a draft confirmation soil and groundwater sampling report will be prepared. The report will summarize analytical results in order to demonstrate source removal and will provide recommendations for NFA, monitoring-only, or additional remedial action, as appropriate. The confirmation sampling report will be submitted to FDEP, Patrick AFB, and AFCEE for review and approval.

As a minimum, the report will contain the following information for Facility 1748:

- This confirmation SAP (as an appendix);
- Site plot plan showing sampling locations;
- Summary of field activities;
- Assessment of soil and groundwater analytical results in comparison to applicable FDEP (1997b) target cleanup levels (Tables 3.1 and 3.2);
- Assessment of the potential for remediation by natural attenuation in groundwater considering FDEP (1997b) target levels (Table 3.2) and geochemical indicator results;
- Laboratory analytical reports and chain-of-custody forms;
- Borehole logs;
- Additional information, as applicable, to meet FDEP (1997b) requirements for a Source Removal Report (Chapter 62-770.300(3)(b) FAC); and
- FDEP (1997b) required information, conclusions, and recommendations for NFA (Chapter 62-770.680, FAC), natural attenuation and monitoring-only (Chapter 62-770.690, FAC), or additional active remediation (Chapter 62-770.700, FAC) or monitoring (Chapter 62-770.750, FAC), as appropriate, based on the confirmation sampling results.

SECTION 6

PATRICK AFB SUPPORT REQUIREMENTS

The following Patrick AFB support is needed prior to the arrival of the Parsons ES field team:

- Assistance in obtaining digging permits;
- Arrangement for site access for Parsons ES personnel;
- Assistance in handling/disposal of purge and rinseate waters in accordance with Section 4.5.

SECTION 7

PROJECT SCHEDULE

The following proposed schedule is contingent upon timely approval of this confirmation SAP and fulfillment of the Patrick AFB support requirements outlined in Section 6.

Event	Date
Submit Draft Confirmation SAP to AFCEE, and Patrick AFB	29 April 1998
Receipt of AFCEE and Patrick AFB Comments	29 May 1998
Submit Final SAP to AFCEE, Patrick AFB, and FDEP*	June 1998
Confirmation Sampling	July 1998
Submit Draft Confirmation Sampling Report to AFCEE and Patrick AFB	October 1998
Receipt of AFCEE and Patrick AFB Comments	November 1998
Submit Draft Final Confirmation Sampling Report to AFCEE, Patrick AFB, and FDEP	December 1998

* FDEP review and comment on the SAP occurred during the 17 April 1998 Petroleum Action Management Plan (PAMP) Meeting.

SECTION 8

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SECTION 9

REFERENCES CITED

- CH2M Hill, 1994. Contamination Assessment Report, Facility 1748, Cape Canaveral Air Station. Tampa, Florida. August.
- CH2M Hill, 1995. Contamination Assessment Report Addendum, Response to FDEP Comments, Facility 1748, Cape Canaveral Air Station. Tampa, Florida. June.
- Engineering-Science Inc. (ES), 1993. Bioventing Test Work Plan for Facilities 1748, 44625D, and Facility 44625E, Cape Canaveral AFS, Florida. Denver, Colorado. November.
- ES, 1994. Draft Interim Pilot Test Results Report for Facilities 1748, 44625D, and Facility 44625E, Cape Canaveral AFS, Florida. Denver, Colorado. May.
- Florida Department of Environmental Protection (FDEP), 1994. Letter Response and Comments to Contamination Assessment Report, Facility 1748, Cape Canaveral Air Station. 8 November.
- FDEP, 1997a. Letter Response and Comments to Remedial Action Plan, Base Cafeteria, Facility 1748, Cape Canaveral Air Station, FL. January 23.
- FDEP, 1997b. Petroleum Contamination Site Cleanup Criteria, Chapter 62-770, Florida Administrative Code. Effective September 23, 1997.
- Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frendt, 1992. Test Plan and Technical Protocol for a Field Treatability Test for Bioventing. January.
- Parsons Engineering Science, Inc. (Parsons ES), 1996a. Letter Report to AFCEE/ERT, Final Tables and Example Letter of Transmittal for AFCEE Bioventing Test Initiative re: Facilities 1748, 44625D, and 44625E at Cape Canaveral AFS, Florida. Denver, Colorado. 13 February.
- Parsons ES, 1996b. Installation Restoration Program Remedial Action Plan, Base Cafeteria, Facility 1748 (SWMU 134), Cape Canaveral Air Station, Florida. Winter Park, Florida. July.
- Parsons ES, 1996c. Letter Report to AFCEE/ERT, Extended Bioventing Testing Results at Fire Training Area 2 (FTA-2), Patrick Air Force Base (AFB); and FTA-2 and Facility 1748, Cape Canaveral Air Force Station (AFS), Florida. Denver, Colorado. 12 July.

Parsons ES, 1997. Letter Report to AFC EE/ERT, Operation and Maintenance Manual, Record Drawings, and Summary of Initial Results for the Expanded Bioventing System Installed at Facilities 44625D and 44625E; Horizontal Vent Well Installation at Facility 1748, Cape Canaveral AS, Florida. Denver, Colorado. 30 May.

APPENDIX B
CONFIRMATION SAMPLING FIELD NOTES

5/14/98-SRA 44625-E

0800- Collected Final Round
of Respiration Test
Readings.

7/29/98-SRA, MAS, MCG
Facility 1748 (CA2)

0730- Onsite at Parsons ES,
Hangar F, Field Office,
Loaded up all equipment to
perform Ground Water Sampling,
and Soil Sampling at the
Base Cafeteria, Facility 1748.
0830- Conducted a Brief Pre-
Field Sampling Meeting to
Discuss what will be going
on (i.e. HACH Kit Testing,
GW Sampling, Soil Sampling)
0845- Onsite at Facility 1748,
Begin setting up for
sampling.

0900- BEGIN WATER LEVEL MEASUREMENTS.

	DTW	TD
MW-1	6.76	12.47
DW-1	6.96	35.75
MW-2	6.77	12.50'
MW-6	7.06	12.20'
MW-8 (NOT FOUND)	- Sub. w/ MW-7	
MW-9	6.78	13.46
MW-7	6.23	13.60

* Notes Could NOT FIND MW8, so Substituted MW7, for a total of 6 wells.

7/29/98 - SRA, MAS, MLG
 1000 - Completed WATER LEVEL
 READINGS / TOTAL DEPTH. BEGIN
 CALIBRATING WATER QUALITY
 INSTRUMENTS.
 HORIBA MULTI-PROBE METER;
 CALIBRATED w/ AUTO-CAL SOLUTION
 (LOT # 1607) EXP. 4-10-2000

READINGS: PH CONDUCTIVITY TURBIDITY
 CAL. SOL = 4.00 4.49 $\mu S/cm$ ϕ NTU;
 METER READING = 3.99 4.48 ϕ

1030 - BEGIN PURGING AT MW2:
 Time/gals PH Cond. TURB. Temp DO Redox
 1036/0.5 6.49 0.502 11 27.2 1.06 -201.4
 1041/1.0 7.02 0.455 4 26.7 0.57 -275.4
 1043/2.0 7.17 0.450 2 26.5 0.37 -288.8
 1045/2.5 7.24 0.451 1 26.4 0.28 -290.2
 1047/3.0 7.26 0.453 1 26.4 0.25 -290.1

1050 - Collected HACH SAMPLE
 FOR ANALYSES: FERROUS,
 NITRATE, NITRITE, MANGANESE,
 AND SULFIDE. RESULTS FROM
 THESE ANALYSES ARE RECORDED
 IN FIELD LOGSHEETS.

7/29/98 - SRA, MAS, MLG
 1050 - HACH TESTING WAS
 PERFORMED BY MICHELLE GODDARD
 (PARSONS ES, ORLANDO), "

1100 - Collected GROUND WATER
 (GW) Samples FROM MW2.
 SAMPLE ID = CA2-MW2 @ 1100
 ANALYSES include: TRPH (FLURO),
 SW8020, SW8310 (PAH's), SULFATE,
 METHANE. Samples WERE Collected
 USING A DISPOSABLE TEFLON BAILER.

1115 - SET-UP ON MW6.
 1135 - BEGIN PURGING MW6:
 Time/gals PH Cond TURB D.O. Temp Redox
 1138/0.5 7.50 0.562 445 0.48 31.5 135.2
 1144/1.5 7.28 0.557 53 0.33 30.8 132.6
 1146/2.0 7.25 0.557 31 0.30 30.3 130.7
 1148/2.5 7.28 0.554 23 0.28 30.3 129.4
 1150/3.0 7.24 0.554 13 0.28 30.4 129.4

1150 - Collected HACH SAMPLE FOR
 FIELD ANALYSES.
 1200 - Collected G.W. SAMPLE;
 FROM MW6. (NOTE: NO METHANE)
 SAMPLE ID: CA2-MW6 @ 1200

7/29/98 - SRA, MAS, MLG

1350 - SETUP ON MW7.

1405 - BEGIN PURGE OF MW7.

Time/Gals PH Cond. Turb. Temp DO REDOX

1408/0.75 7.70 0.588 61 30.4 0.33 -101.9

1412/1.5 7.73 0.586 70 30.3 0.26 -114.4

1414/2.0 7.75 0.583 29 30.2 0.23 -123.1

1416/2.5 7.74 0.585 8 29.9 0.22 -137.6

1418/3.0 7.74 0.585 6 29.7 0.21 -147.7

1420 - COLLECTED HACH SAMPLE

FOR FIELD ANALYSES.

1430 - COLLECTED G.W. SAMPLE

AT MW7, (NOTE: NO METHANE)

SAMPLE ID = C1A2 - MW7 @ 1430

1500 - DUE TO SEVERE THUNDER-

STORMS IN THE VICINITY,

A "LEVEL 2" WARNING WAS

GIVEN: BASE-WIDE, WHICH

REQUIRES ALL PERSONNEL TO

BE INSIDE A BUILDING OR

VEHICLE. WE BEGAN SECURING

ALL EQUIP. A

FACILITY 1748

7/29/98 - SRA, MAS, MLG

1600 - AFTER WAITING - BUT T/S

FOR 1-HOUR, A SECOND

"LEVEL 2" WARNING WAS

EXTENDED TO AT LEAST 1700.

WE SECURED THE SITE AT

THIS TIME

1630 - LEFT SITE. WILL RETURN

@ 0700, 7/30/98.

7/30/98 - SRA, MAS, MLG
 0700 - ONSITE AT FAC. 1748
 0730 - CALIBRATED HORIBA METER
 USING AUTO-CAL SOLUTION,
 LOT# 1607, EXP. 4-10-200
 PH Cond Turb.
 Cal. Sol. = 4.00 4.49 ϕ
 HORIBA = 3.99 4.49 ϕ
 ...
 0745 - Setup on MW9 Location.
 0805 - BEGIN PURGE OF MW9;
 Time/Gals PH Cond Turb Temp °C DO, REDOX
 0808/0.5 5.90 0.801 ϕ 28.6 0.28 -267.8
 0811/1.0 6.59 0.756 ϕ 28.9 0.22 -279.9
 0817/2.0 6.21 0.798 ϕ 28.9 0.19 -282.5
 0820/2.5 6.89 0.768 ϕ 28.9 0.19 -282.7
 0822/3.0 6.83 0.766 ϕ 29.0 0.18 -286.9
 0824/3.5 6.88 0.767 ϕ 29.8 0.17 -293.1

0825 - Collected HACH SAMPLE
 FOR FIELD ANALYSES.
 0830 - Collected EQUIPMENT
 BLANK FROM BAILER PRIOR
 TO SAMPLING.
 Sample I.D. = CA2-EQPBLK@0830

FACILITY 1748
 7/30/98 - SRA, MAS, MLG
 0840 - Collected G.W. SAMPLE
 FROM MW9, (NO METHANE)
 Sample I.D. = CA2-MW9@0840
 0845 - Setup AT DW-1 Location
 0900 - BEGIN PURGE AT DW-1
 Time/Gals PH Cond Turb Temp °C DO, REDOX
 0903/0.5 7.31 0.516 1 26.9 0.37 -224.1
 0925/5.0 7.35 0.594 ϕ 26.8 0.18 -282.0
 0943/10.0 7.39 0.628 2 27.0 0.14 -279.8
 0950/12.0 7.42 0.631 ϕ 26.5 0.14 -280.6
 0953/13.0 7.43 0.638 ϕ 26.5 0.13 -282.7
 0957/14.0 7.42 0.641 ϕ 26.6 0.13 -285.9
 1000/15.0 7.47 0.644 ϕ 26.5 0.13 -288.9
 ...
 1000 - Collected HACH SAMPLE
 FOR FIELD ANALYSES.
 1010 - Collected G.W. SAMPLE
 AT DW1 Location. (4 Duplicate)
 Sample I.D. = CA2-DW1@1010
 * ALSO = CA2-DUP1

FACILITY 1748				
7/30/98 - SRA, MAS, MLG				
1015 - SETUP ON MW1 LOCATION.				
1030 - BEGIN PURGE OF MW1:				
Time/Gals	PH	Cond	TEMP	DO REDOX
1032/0.5	6.91	1.11	73	29.1 0.18 - 336.
1035/1.0	7.00	0.920	37	29.0 0.14 - 343.
1038/2.0	7.07	0.836	27	29.0 0.12 - 345.9
1040/2.5	7.09	0.829	17	29.0 0.12 - 343.4
1042/3.0	7.13	0.818	16	29.0 0.11 - 340.0

1045 - COLLECTED HACH SAMPLE FOR FIELD ANALYSES.

1050 - COLLECTED G.W. SAMPLE AT MW1 LOCATION. (INCL. METHANE)

SAMPLE ID: CA2-MW1 @ 1050

NOTE: SHEEN ON SURFACE OF WATER DURING SAMPLING.

*NOTE: ALL SOIL SAMPLES COLLECTED AT FACILITY 1748 WILL BE ANALYZED FOR: FL-PRO (TRPH), SW8020, SW 8310 (PAH'S)

FACILITY 1748

7/30/98 - SRA MAS

1200-1300 - DECON HAND AUGERS (HA) CUT HA HOLES FOR SOIL BORINGS LOCATED IN THE ASPHALT.

1320 - COLLECTED RINSEATE BLANK SAMPLE FROM A PRE-DECONNED HA BUCKET.

SAMPLE TIME/ID: CA2-SBEPBCK @ 1320

1330 - CALIBRATED PID METER (Mini-RAE) TO 100 ppm Isobutylene CAL GAS.

1335 - BEGIN HA AT SB1 LOCATION.

DEPTH (FT) PPMV SOIL DESCRIP.

0-0.5 N/S ASPHALT

0.5-1.5 N/S LIMESTONE BASE

2.0-3.0 0.0 LT. GRAY FINE SAND

4.0 0.0 BRN/ORANGE FINE

TO MED SAND.

5.0 0.0 SAA

6.0 0.0 GRAY MED SAND

6.5 N/S W/SHELL FRAG.

SAA - SATURATED

W.T.

*SAMPLING TIME/ID: CA2-SB1-6

@ 1340

Facility 1748	
7/30/98 - SRA, MAS	
1350 - BEGIN HA @ SB2 LOCATION,	
DEPTH (FT)	PPMV SOIL DESCR.
0-0.5	N/S ASPHALT
0.5-1.5	N/S LIMESTONE
2.0-3.0	N/S LT. GRAY FINE SAND
4.0	6.0 BRN/ ORANGE MED. SAND
5.0	22.0 SAA ↑
6.0	45.0 GRAY, MED SAND
	w/ SHELL FRAG.
Sample Time/ I.D. = CA2-SB2-6	
@ 1410	
1415 - BEGIN HA @ SB3 LOCATION,	
DEPTH (FT)	PPMV SOIL DESCR.
0-1.5	N/S GRASS, TOP SOIL,
	FILL MAT.
2.0-3.0	N/S LT. GRAY FINE SAND
4.0	0.9 BRN/ ORANGE MED. SAND
5.0	15.0 SAA ↑
6.0	78.0 GRAY, MED SAND,
	w/ SHELL FRAG.
Sample Time/ I.D. = CA2-SB3-6	
@ 1435	

Facility 1748	
7/30/98 - SRA - MAS	
1440 - BEGIN HA @ SB4 LOCATION,	
NOTE: Collected Duplicate AT	
	THIS LOCATION
DEPTH (FT)	PPMV SOIL DESCR.
0-0.5	N/S ASPHALT
0.5-1.5	N/S LIMESTONE BASE
2.0-3.0	N/S LT. GRAY FINE SAND
4.0	5.5 BRN/ ORANGE MED SAND
5.0	18.6 SAA ↑
6.0	63.0 GRAY, MED. SAND
	w/ SHELL FRAG.
Sample Time/ I.D. = CA2-SB4-6	
@ 1505	
1510 - BEGIN HA @ SB5 LOCATION,	
DEPTH (FT)	PPMV SOIL DESCR.
0-1.5	N/S GRASS, TOP SOIL
	FILL MAT.
2.0-3.0	N/S LT. GRAY FINE SAND
4.0	5.8 BRN SAND/ PEA
	GRAVEL FROM TANK REM.
5.0	4.8 SAA ↑
6.0	24.0 SAA ↑
Sample Time/ I.D. = CA2-SB5-6	
@ 1525	

FACILITY 1748

7/30/98-SRA, MAS

DEPTH (FT.)	PPMV	SOIL DESCRIP.
0-1.5	N/S	GRASS TOP SOIL, FILL
2.0-3.0	N/S	LT. GRAY FINE SAND
4.0	14.7	BRN/ORANGE MED. SAND
5.0	51.0	SAA ↑
6.0	82.0	GRAY, MED. SAND, w/ SHELL FRAG.

Sample Time/I.D. = CA2-SB6-6

@ 154.5

1550-BEGIN HA @ SB7 location.

DEPTH (FT.)	PPMV	SOIL DESCRIP.
0-0.5	N/S	ASPHALT
0.5-1.5	N/S	LIMESTONE BASE
2.0-3.0	N/S	LT. GRAY, FINE SAND
4.0	20.0	BRN/ORANGE MED. SAND
5.0	19.5	SAA ↑
6.0	85.0	GRAY, VERY MOIST, MED. SAND w/ SHELL FRAG.

Sample Time/I.D. = CA2-SB7-6

@ 1600

FACILITY 1748

7/30/98-SRA, MAS

DEPTH (FT.)	PPMV	SOIL DESCRIP.
0-1.5	N/S	GRASS TOP SOIL, FILL MAT.
2.0-3.0	N/S	LT. GRAY FINE SAND
4.0	10.4	BRN/ORANGE MED. SAND
5.0	10.5	SAA ↑
6.0	35.6	GRAY, VERY MOIST, MED. SAND w/ SHELL

TANK FILL

MATERIAL

Sample Time/I.D. = CA2-SB8-6

@ 1615

1620-BEGIN ~~SB~~^{SAA} HA @ SB9 location.

DEPTH (FT.)	PPMV	SOIL DESCRIP.
0-1.5	N/S	GRASS TOP SOIL, FILL MAT.
2.0-3.0	N/S	LT. GRAY FINE SAND
4.0	23.0	BRN/ORANGE MED. SAND
5.0 SRA		
5.0	11.4	SAA ↑
6.0	31.0	GRAY MED SAND w/ SHELL FRAG.

Sample Time/I.D. = CA2-SB9-6

@ 1630

7/30/98 - Facility 1748

SRA, MAS

1645-1800 - Complete C.O.C.'s

PREPARE SAMPLES FOR SHIPMENT.

7/31/98 - Facility 1748 & 44625 D/E

SRA, MAS

0700-0930 - REPAIRED ASPHALT PATCHES AT FAC 1748.

1000-1400 - DISCONNECTED ELECTRIC

TO BLOWER @ FAC 44625 D/E;

ALSO CAPPED OFF HVW'S

MANIFOLD TO BLOWER SHED.

REMOVED ANCHOR NUTS,

BUT COULD NOT REMOVE

BOLTS FROM CONCRETE.

NOTE: THE SHED WILL NEED TO

BE LIFTED DIRECTLY UP

~ 6-INCHES IN ORDER TO

CLEAR THE BOLTS, THEN IT

CAN BE MOVED TO THE SIDE.

ELECTRIC POWER WAS ALSO

SHUT-OFF AT THE BREAKER

PANEL. SPARE PARTS TO THE

BLOWER (IE, GAUGES, FILTERS,

ETC.) WERE PASSED ON TO THE

PARSONS ES - ORLANDO OFFICE.

APPENDIX C
LABORATORY ANALYTICAL RESULTS



SPECIALIZED ASSAYS INC. • 2960 Foster Creighton Dr. • P.O. Box 40566 • Nashville, Tennessee 37204-0566
615-726-0177 • 1-800-765-0980 • Fax 615-726-3404

CASE NARRATIVE

WCO
9/15/98
W/O ELD

Client: Parsons Engineering Science
Attn: Lynnea Peterson
1700 Broadway, Suite 900
Denver, CO 80290

Client Project: Facility 1748 CA2 Cape Canaveral No. Samples/Matrix: 10 Water; 10 soil

Laboratory Project: 108621

Date Received: 07/31/98

Date Collected: 07/29/98 - 07/30/98

Sample Receipt Notes: All samples were received in good condition. One complete sample set of water containers labeled on the bottles as CA2-MW-1 were received with the shipment. Per instruction From Lynnea Peterson, this sample was logged into the laboratory system and analyzed for all parameters listed on the chain of custody for other samples. All containers were properly preserved, and no other abnormalities were noted.



QA/QC Summary:

Volatile Organic Method 8021B, Water:

All surrogates, matrix spikes, matrix spike duplicate, and laboratory control samples were within acceptable quality control limits. All samples were analyzed within method specified holding times. Sample 98-A90057, ID. CA2-MW6, was used as the project matrix spike/spike duplicate for this analytical batch (Batch # 1659). Sample CA2-MW-1 does show peaks at the correct retention time for the mono and dichlorobenzenes on the primary detector (PID); however, these peaks do not confirm as target compounds on the second (HALL) detector. These compounds are reported negative based on this lack of confirmation.

Volatile Organic Method 8021B, Soil:

All of the soil samples analyzed for volatile organics by method 8021B except CA2-SB9-6 required secondary dilutions at 50 X because of the sample matrix. The original analysis for all samples except CA2-SB8-6 and CA2-SB9-6 had one or more surrogates outside QC limits due to the sample matrix. All surrogate recoveries were acceptable on the secondary dilution analyses. Also, because of the matrix interferences, matrix spike and spike duplicate analysis on sample CA2-SB1-6, Lab No. 98-A90102, do not report recoveries for m,p- or o-Xylene. The recoveries for all compounds in the laboratory control analysis are within required limits for this project. Because of the nature of the analysis and the interferences present on the primary detector (PID), results for the mono and dichlorobenzenes are reported as not detected based upon the lack of confirmation on the secondary (HALL) detector.

Semivolatile Organic Method 8310 (Water):

Because insufficient sample was supplied to allow for Matrix spike/Spike duplicate analysis with this sample delivery group, this QC determination was performed using de-ionized water as with the sample labeled laboratory control. The analysis reported as Matrix spike had a low recovery for Naphthalene and acceptable but lower than usual recovery for Acenaphthylene. The laboratory control and the analysis reported as the Spike duplicate had acceptable recovery for these compounds. Because of the low recoveries on the matrix spike, the RPD on the spike pair for Naphthalene and Acenaphthylene are above the target QC limits for this project. Because two of the three deionized water spike analyses spiked with different source QC standard solutions had acceptable recovery for the two compounds, no further action was taken. All surrogate recoveries are within acceptable ranges, with sample CA2-MW-1 analyzed at a 10-fold dilution and the surrogate reported as diluted below detectable levels.

Semivolatile Organic Method 8310 (Soil):

All samples were analyzed initially on dilution due to the sample matrix. Three samples, CA2-SB4-6, CA2-SB5-6, and CA2-DUP1-6, also required analysis at a secondary dilution because of matrix interferences. On the original analysis at 40-fold dilution for these three samples, only a portion of the target compound list is reported. The remainder of the compounds were not reported due to matrix interferences with the analytical detectors. These compounds are reported on the secondary 200-fold dilution analysis. Sample CA2-SB1-6 was chosen for the matrix spike/spike duplicate analysis for this analytical batch. Due to the level of contamination in the extracts and the required dilution for analysis, all spiked compounds were diluted below detectable levels. All recoveries for the laboratory control analysis were within required limits.



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Methanol Method RSKSOP175 –

The Methanol recovery for the matrix spike analysis on sample CA2-MW2 was within required limits. Calibration and control standards were within acceptable limits.

FLA PRO (Water):

All surrogate recoveries are within the required statistical limits. Matrix spike/Spike duplicate and laboratory control analyses conducted on de-ionized water were within required limits. There was insufficient sample supplied for spike analysis on a project specific sample.

FLA PRO (Soil):

Surrogate recoveries were within acceptable limits for samples CA2-SB8-6 and CA2-SB9-6. All other samples were analyzed on dilutions of a magnitude which resulted in the surrogates diluted below detectable levels. Matrix spike recoveries for sample CA2-SB1-6 were also diluted below reportable levels due to sample matrix contamination. Results for the laboratory control spike were within required limits.

If you have any technical questions as you review this data, please call me at 1-800-765-0980. Thank you for the opportunity to work with Parson's Engineering Science on this project.

Johnny A. Mitchell
Operations Manager
Specialized Assays, Inc.

Enclosures

SPECIALIZED ASSAYS
ENVIRONMENTAL

7A- 030730

REFERRING CLIENT

Account: 8185
Parsons Engineering/AFCEE Exte
Doug Scott
1700 Broadway Ste 900
Denver, CO 80290
Ph: 303-831-8100 Fax: 303-831-8208



2960 Foster Creighton Drive
Nashville, TN 37204
615-726-0177, 800-765-0980
FAX 615/726-3404

Specialized Assays: (800) 765-0980

IN CONTROL NUMBER (FOR LAB USE ONLY)

108621

PROJECT #

726876,26122

P.O. #

726876,26122

PROJECT NAME

FACILITY 1748 (CA2)
CAPE CANAVERAL AFS

LAB USE ONLY

LAB USE ONLY
ACC#

SAMPLE DESCRIPTION

DATE

TIME

COMP

GRAB

OF CONT

ANALYSIS REQUESTED

B-A90056

CA2-MW2

7/29/98

1100

X

7

SW8020, SW8310 (PAH's),
FL-PRO (TRPH), SULFATE (SW905),
METHANE (RSK50P175)

B-A90057

CA2-MW6

7/29/98

1200

X

5

SW8020, SW8310 (PAH's),
FL-PRO (TRPH), SULFATE (SW905)

B-A90058

CA2-MW7

7/29/98

1430

X

5

SW8020, SW8310 (PAH's),
FL-PRO (TRPH), SULFATE (SW905)

B-A90059

CA2-MW9

7/30/98

0840

X

5

SW8020, SW8310 (PAH's),
FL-PRO (TRPH), SULFATE (SW905)

B-A90060

CA2-MW1
-DW1

7/30/98

1010

X

5

SW8020, SW8310 (PAH's),
FL-PRO (TRPH), SULFATE (SW905)

B-A90061

CA2-DUP1

7/30/98

X

5

SW8020, SW8310 (PAH's),
FL-PRO (TRPH), SULFATE (SW905)

B-A90062

CA2-EQPBLK

7/30/98

0830

X

2

SW8020

B-A90063

TRIP BLANK

B-A90064

AA MW-1 extra

Relinquished by: (Signature)

Steve Archabal

Date / Time

7/30/98

Date / Time

Date / Time

Date / Time

Date / Time

Date / Time

Received by: (Signature)

Received by: (Signature)

Received by: (Signature)

Received by: (Signature)

Received for Laboratory by:

P. J. K. 3

Remarks

qpc

SAI Project #:

Date /

7/31/98

For further assistance in completing the chain of custody form please refer to the instructions found on the oppc

SPECIALIZED ASSAYS
ENVIRONMENTAL

7A- 030733

REFERRING CLIENT

Account: 8185
Parsons Engineering/AFCEE Exte
Doug Scott
1700 Broadway Ste 900
Denver, CO 80290
Ph: 303-831-8100 Fax: 303-831-8208



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Nashville, TN 37204
615-726-0177, 800-765-0980
FAX 615/726-3404

Specialized Assays: (800) 765-0980

CONTROL NUMBER (FOR LAB USE ONLY)

108621

PROJECT #

726876.26122

PO #

726876.26122

PROJECT NAME

FACILITY 1748 (CA2)
CAPE CANAVERAL AFS

(Signature - Please Print)

Steve Archabal - STEVE ARCHABAL

FOR LAB USE ONLY
ACC#

SAMPLE DESCRIPTION

DATE

TIME

COMP

GRAB

OF CONT

ANALYSIS REQUESTED

CA2-SBERPBLK 7/30/98 1320 X 2 SW8020

CA2-SB1-6 7/30/98 1340 X 1 FL-PRO (TRPH), SW8020,
SW8310 (PAH's)CA2-SB2-6 7/30/98 1410 X 1 FL-PRO (TRPH), SW8020,
SW8310 (PAH's)CA2-SB3-6 7/30/98 1435 X 1 FL-PRO (TRPH), SW8020,
SW8310 (PAH's)CA2-SB4-6 7/30/98 1505 X 1 FL-PRO (TRPH), SW8020,
SW8310 (PAH's)CA2-SB5-6 7/30/98 1525 X 1 FL-PRO (TRPH), SW8020,
SW8310 (PAH's)CA2-SB6-6 7/30/98 1545 X 1 FL-PRO (TRPH), SW8020,
SW8310 (PAH's)CA2-SB7-6 7/30/98 1600 X 1 FL-PRO (TRPH), SW8020,
SW8310 (PAH's)CA2-SB8-6 7/30/98 1615 X 1 FL-PRO (TRPH), SW8020,
SW8310 (PAH's)CA2-SB9-6 7/30/98 1630 X 1 FL-PRO (TRPH), SW8020,
SW8310 (PAH's)

Relinquished by: (Signature)

Date / Time

Received by: (Signature)

Received for Laboratory by:

Date / Time

Relinquished by: (Signature)

Date / Time

Received by: (Signature)

Remarks

Relinquished by: (Signature)

Date / Time

Received by: (Signature)

Relinquished by: (Signature)

Date / Time

Received by: (Signature)

SAI Project #:

For further assistance in completing the chain of custody form please refer to the instructions found on the opposite

7A- 030734

Specialized Assays: (800) 765-0980

CONTROL NUMBER (FOR LAB USE ONLY)

108621

PROJECT -

726876.26122

P.O. #	
--------	--

726876.26122

(Please Signatures Please Print)

Signature: Please Print: Steve Archabal - STEVE ARCHABAL

PROJECT NAME

PROJECT NAME FACILITY 1748 (CA2)
CAPE CANAVERAL AFS

C. LAB USE ONLY
ACC#

SAMPLE DESCRIPTION

DATE _____


TIME

COMP

GRAB

END OF COPY

ANALYSIS REQUESTED

•  1 1 1 1

CA2-DUPI-6

7/30/98

—

X

11

FL-PRO (TRPH), SW 8020,
SW 8310 (PAH's)

Required by: (Signature)

Date / Time

Received by: (Signature)

Received for Laboratory by:

Date / Time

...ed by: (Signature)

Date / Time

Received by: (Signature)

Remarks

Redacted by: (Signature)

Date / Time

Received by: (Signature)

 Approved by: (Signature)

Date / Time

Received by: (Signature)

SAI Project #:

for further assistance in completing the chain of custody form please refer to the instructions found on the opposite :

Cooler Receipt Form

Client: PearsonsCooler Received On: 7/31/98 And Opened On: 7/31/98 By: Patrick ButlerPatrick Butler
(Signature)1. Temperature of Cooler when opened 4°C2. Were custody seals on outside of cooler and intact? Yes Noa. If yes, what kind and where: 2 front/backb. Were the signature and date correct? Yes No3. Were custody papers inside cooler? Yes No4. Were custody papers properly filled out (ink, signed, etc)? Yes No5. Did you sign the custody papers in the appropriate place? Yes No6. What kind of packing material was used? bubblewrap7. Was sufficient ice used (if appropriate)? Yes No8. Did all bottles arrive in good condition (unbroken)? Yes No9. Were all bottle labels complete (#, date, signed, pres, etc)? Yes No10. Did all bottle labels and tags agree with custody papers? Yes No11. Were correct bottles used for the analysis requested? Yes No12. If present, were VOA vials checked for absence of air bubbles and noted if found? Yes No13. Was sufficient amount of sample sent in each bottle? Yes No14. Were correct preservatives used? Yes No

15. Corrective action taken, if necessary:

a. Name of person contacted: _____

b. Date _____

FedFedEx
Tracking
Number

807441924683

In #
IC No 0210

SMA33

From

7/30/98

Phone 602 852-9110

Phone 602 852-9110

PARSONS ENGINEERING SCIENCE, INC.

3875 N. 44th STREET SUITE 250

PHOENIX AZ ZIP 85018.

Depot/Satellite

Our Internal Billing Reference Information

To

Phone 602 852-9110

To

Depot/Satellite

To

Phone 602 852-9110

To

Phone 602 852-9110

For HOLD at FedEx Location check here

Hold Weekday

Hold Saturday

Saturday Delivery

Next Business Day

Next Business Day

Next Business Day

Next Business Day

Next Business Day

Next Business Day

Next Business Day

4a Express Package Service Packages under 150 lbs

FedEx Priority Overnight

FedEx Standard Overnight

FedEx 2Day

FedEx Overnight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

FedEx Overnight Freight

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From 7/30/98

STEVE ARCHIBAL

PARSONS ENGINEERING SCIENCE, INC.

3875 N. 44TH STREET SUITE 250

PHOENIX AZ 85018
State ZIP Dept./Floor/Surface/Room

Our Internal Billing Reference Information

To
SAMPLE RECEIVING
Office 615 724-9177

SAVED BY THE LORD

☐ **Check here if residence**
 telephone area
 number (city/state)

Don't Know/No Answer

WATKINSVILLE
GA 30687-9710

For HOLD at FedEx location check here

<input type="checkbox"/> Hold Weekday Hold a package with FedEx (not Saturday)	<input type="checkbox"/> Hold Saturday Hold a package with FedEx (not Saturday) and FedEx Home Delivery (HDD only)	<input type="checkbox"/> Saturday Delivery Deliveries on Saturdays are available for FedEx Home Delivery (HDD) only	<input type="checkbox"/> Next Business Day Delivery Deliveries on the next business day are available for FedEx Express® and FedEx International Priority®
---	---	---	---

*Not available for all services. For more information, visit fedex.com/hold

The image shows a vertical strip of a document page. The page is heavily degraded with significant noise and artifacts. At the top right corner, there is a jagged, irregular shape. The page contains a series of horizontal lines, likely representing a list or table. There are several large black rectangular blocks of varying sizes, which appear to be redactions or artifacts from the scanning process. The overall quality is poor, with a lot of black noise and a high level of contrast.

[illegible]

Questions?
Call 1-800-Go-FedEx® (800) 463-3339

Call 1-800-Go-FedEx® (800)463-3339

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100-443881-100
 100-443881-100
 100-443881-100

0270

Form 40

☒ Express Package Service Packages under 150 lbs.
☒ Fedex Priority Overnight
☐ Fedex Standard Overnight
 (We'll guarantee a faster delivery)

Delivery instructions (e.g. Deliver to front door)
 (We'll call you first)

☐ **FedEx First Overnight** (If there are no business units using overnight to start business)

☐ **FedEx 2Day** (Select business day)

☐ **FedEx Express Saver** (If Fed business day)

_____ (If there are no business units available, please enter a time. One number only)

4b Express Freight Service Packages over 150 lbs. Delivery commitment only
30 days in service time

☐ FedEx Overnight (Next business day) ☐ FedEx 2Day Freight (See back for details) ☐ FedEx Express Saver Freight (No in business days)

Call for delivery schedule. See back for detailed descriptions of freight services!

5 Packaging ☐ FedEx Letter ☐ FedEx Pkg ☐ FedEx Tube ☒ Other ☐ Registered sales tax (state)

Special Handling

Does this shipment contain dangerous goods? ☒ No ☐ Yes

☐ Dry Ice ☐ Dry Ice - Return _____ to _____

☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No

(List here what has been used)

☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No ☐ Yes ☐ No

☐ Cargo Aircraft Only

*The system was designed to be improved by adding more options.

Payment

☐ Bill to ☐ Sender ☐ Recipient ☐ Credit Card ☐ Cash
☐ Bill to ☐ Sender ☐ Recipient ☐ Credit Card ☐ Cash

_____ **Source:** Federal Reserve Bank of Cleveland

Total Packages	Total Weight	Total Declared Value	Total Charges
1	81	\$ 00	\$

*We warrant that the actual weight and value of the contents are as stated on the shipping label.
 *We warrant that the actual weight and value of the contents are as stated on the shipping label.

Credit Card Auth

8 Holena Sinaloa



SPECIALIZED ASSAYS, INC.

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

MW-1

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-A90064
Date Sampled::
Date Received: 7/31/98
Analysis Date: 8/ 5/98
Analysis Time: 4:13
Sample QC Group: 1659

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	7.3	.....
108-90-7	Chlorobenzene	2.0	..... U
95-50-1	1,2-Dichlorobenzene	4.0	..... U
541-73-1	1,3-Dichlorobenzene	4.0	..... U
106-46-7	1,4-Dichlorobenzene	3.0	..... U
100-41-4	Ethylbenzene	39.4	.....
108-88-3	Toluene	2.0	..... U
108-38-3	m,p-Xylenes	1.1	..... J
95-47-6	o-Xylene	2.0	..... U
1634-04-4	MTBE	2.0	..... U

000022



SPECIALIZED ASSAYS, INC.

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

MW-1

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 10.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Vol Extracted: 920. ml
Extract Vol: 1.00 ml

Lab Sample ID: 98-A90064
Date Sampled::
Date Received: 7/31/98
Analysis Date: 8/ 7/98
Analysis Time: 11:40
Sample QC Group: 2293

Extraction Date: 8/ 4/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
	Naphthalene	196	U
83-32-9	Acenaphthene	196	U
120-12-7	Anthracene	71.7	U
206-44-0	Fluoranthene	22.8	U
7782-41-4	Fluorene	5.22	J
129-00-0	Pyrene	29.3	U
56-55-3	Benzo(a)anthracene	2.28	
50-32-8	Benzo(a)pyrene	2.5	U
205-99-2	Benzo(b)fluoranthene	1.96	U
207-08-9	Benzo(k)fluoranthene	1.85	U
218-01-9	Chrysene	16.3	U
53-70-3	Dibenzo(a,h)anthracene	3.26	U
193-39-5	Indeno(1,2,3-cd)pyrene	4.67	U
208-96-8	Acenaphthylene	250	U
191-24-2	Benzo(g,h,i)perylene	8.26	U
85-01-8	Phenanthrene	69.6	U

000023



SPECIALIZED ASSAYS, INC.

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CA2-MW2

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-A90056
Date Sampled:: 7/29/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 22:07
Sample QC Group: 1659

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	2.0	U
108-90-7	Chlorobenzene	2.0	U
95-50-1	1,2-Dichlorobenzene	4.0	U
541-73-1	1,3-Dichlorobenzene	4.0	U
106-46-7	1,4-Dichlorobenzene	3.0	U
100-41-4	Ethylbenzene	2.0	U
108-88-3	Toluene	2.0	U
108-38-3	m,p-Xylenes	2.0	U
95-47-6	o-Xylene	2.0	U
1634-04-4	MTBE	2.0	U

000008

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-MW2**

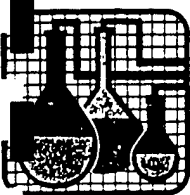
Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Vol Extracted: 950. ml
Extract Vol: 1.00 ml

Lab Sample ID: 98-A90056
Date Sampled:: 7/29/98
Date Received: 7/31/98
Analysis Date: 8/ 7/98
Analysis Time: 13:31
Sample QC Group: 2293
Extraction Date: 8/ 4/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	18.9	U
83-32-9	Acenaphthene	18.9	U
120-12-7	Anthracene	6.95	U
206-44-0	Fluoranthene	2.21	U
7782-41-4	Fluorene	2.21	U
129-00-0	Pyrene	2.84	U
56-55-3	Benzo(a)anthracene	0.14	U
50-32-8	Benzo(a)pyrene	0.24	U
205-99-2	Benzo(b)fluoranthene	0.19	U
207-08-9	Benzo(k)fluoranthene	0.18	U
218-01-9	Chrysene	1.58	U
53-70-3	Dibenzo(a,h)anthracene	0.32	U
193-39-5	Indeno(1,2,3-cd)pyrene	0.45	U
208-96-8	Acenaphthylene	24.2	U
191-24-2	Benzo(g,h,i)perylene	0.8	U
85-01-8	Phenanthrene	6.74	U

000009

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-MW6**

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-A90057
Date Sampled:: 7/29/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 22:44
Sample QC Group: 1659

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	2.0	U
108-90-7	Chlorobenzene	2.0	U
95-50-1	1,2-Dichlorobenzene	4.0	U
541-73-1	1,3-Dichlorobenzene	4.0	U
106-46-7	1,4-Dichlorobenzene	3.0	U
100-41-4	Ethylbenzene	2.0	U
108-88-3	Toluene	2.0	U
108-38-3	m,p-Xylenes	2.0	U
95-47-6	o-Xylene	2.0	U
1634-04-4	MTBE	2.0	U

000010



SPECIALIZED ASSAYS, INC.

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CA2-MW6

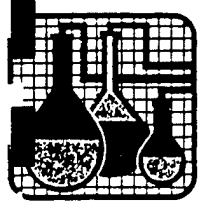
Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Vol Extracted: 920. ml
Extract Vol: 1.00 ml

Lab Sample ID: 98-A90057
Date Sampled:: 7/29/98
Date Received: 7/31/98
Analysis Date: 8/ 7/98
Analysis Time: 14:07
Sample QC Group: 2293
Extraction Date: 8/ 4/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	19.6	U
83-32-9	Acenaphthene	19.6	U
120-12-7	Anthracene	7.17	U
206-44-0	Fluoranthene	2.28	U
7782-41-4	Fluorene	2.28	U
129-00-0	Pyrene	2.93	U
56-55-3	Benzo(a)anthracene	0.14	U
50-32-8	Benzo(a)pyrene	0.25	U
205-99-2	Benzo(b)fluoranthene	0.2	U
207-08-9	Benzo(k)fluoranthene	0.18	U
218-01-9	Chrysene	1.63	U
53-70-3	Dibenzo(a,h)anthracene	0.33	U
193-39-5	Indeno(1,2,3-cd)pyrene	0.47	U
208-96-8	Acenaphthylene	25	U
191-24-2	Benzo(g,h,i)perylene	0.83	U
85-01-8	Phenanthrene	6.96	U

000011

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-MW7**

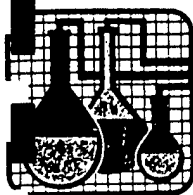
Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-A90058
Date Sampled:: 7/29/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 23:20
Sample QC Group: 1659

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	2.0	.... <u>U</u>
106-90-7	Chlorobenzene	2.0	.... U
95-50-1	1,2-Dichlorobenzene	4.0	.... U
541-73-1	1,3-Dichlorobenzene	4.0	.... U
106-46-7	1,4-Dichlorobenzene	3.0	.... U
100-41-4	Ethylbenzene	2.0	.... U
108-88-3	Toluene	2.0	.... U
108-38-3	m, p-Xylenes	2.0	.... U
95-47-6	o-Xylene	2.0	.... U
1634-04-4	MTBE.....	2.0	.... U

000012

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-MW7**

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Vol Extracted: 930. ml
Extract Vol: 1.00 ml

Lab Sample ID: 98-A90058
Date Sampled:: 7/29/98
Date Received: 7/31/98
Analysis Date: 8/ 7/98
Analysis Time: 14:44
Sample QC Group: 2293

Extraction Date: 8/ 4/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
	Naphthalene	19.4	U
83-32-9	Acenaphthene	19.4	U
120-12-7	Anthracene	7.1	U
206-44-0	Fluoranthene	2.26	U
7782-41-4	Fluorene	2.26	U
129-00-0	Pyrene	2.9	U
56-55-3	Benzo(a)anthracene	0.14	U
50-32-8	Benzo(a)pyrene	0.25	U
205-99-2	Benzo(b)fluoranthene	0.19	U
207-08-9	Benzo(k)fluoranthene	0.18	U
218-01-9	Chrysene	1.61	U
53-70-3	Dibenzo(a,h)anthracene	0.32	U
193-39-5	Indeno(1,2,3-cd)pyrene	0.46	U
208-96-8	Acenaphthylene	24.7	U
191-24-2	Benzo(g,h,i)perylene	0.82	U
85-01-8	Phenanthrene	6.88	U

000013



SPECIALIZED ASSAYS, INC.

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CAZ-MW9

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-A90059
Date Sampled:: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 23:57
Sample QC Group: 1659

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	2.0	U
108-90-7	Chlorobenzene	2.0	U
95-50-1	1,2-Dichlorobenzene	4.0	U
541-73-1	1,3-Dichlorobenzene	4.0	U
106-46-7	1,4-Dichlorobenzene	3.0	U
100-41-4	Ethylbenzene	2.0	U
108-88-3	Toluene	2.0	U
108-38-3	m, p-Xylenes	2.0	U
95-47-6	o-Xylene	2.0	U
1634-04-4	MTBE	2.0	U

000014

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-MW9**

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Vol Extracted: 920. ml
Extract Vol: 1.00 ml

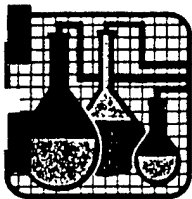
Lab Sample ID: 98-A90059
Date Sampled:: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 7/98
Analysis Time: 15:21
Sample QC Group: 2293

Extraction Date: 6/ 4/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
	Naphthalene	19.6	U
83-32-9	Acenaphthene	19.6	U
120-12-7	Anthracene	7.17	U
206-44-0	Fluoranthene	2.28	U
7782-41-4	Fluorene	2.28	U
129-00-0	Pyrene	2.93	U
56-55-3	Benzo(a)anthracene	0.14	U
50-32-8	Benzo(a)pyrene	0.25	U
205-99-2	Benzo(b)fluoranthene	0.2	U
207-08-9	Benzo(k)fluoranthene	0.18	U
218-01-9	Chrysene	1.63	U
53-70-3	Dibenzo(a,h)anthracene	0.33	U
193-39-5	Indeno(1,2,3-cd)pyrene	0.47	U
208-96-8	Acenaphthylene	25	U
191-24-2	Benzo(g,h,i)perylene	0.83	U
85-01-8	Phenanthrene	6.96	U

000015

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CA2-DW1

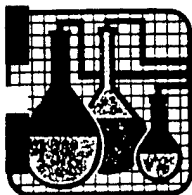
Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-A90060
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 5/98
Analysis Time: 1:10
Sample QC Group: 1659

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	2.0	U
108-90-7	Chlorobenzene	2.0	U
95-50-1	1,2-Dichlorobenzene	4.0	U
541-73-1	1,3-Dichlorobenzene	4.0	U
106-46-7	1,4-Dichlorobenzene	3.0	U
100-41-4	Ethylbenzene	2.0	U
108-88-3	Toluene	2.0	U
108-38-3	m, p-Xylenes	2.0	U
95-47-6	o-Xylene	2.0	U
1634-04-4	MTBE	2.0	U

000016



SPECIALIZED ASSAYS, INC.

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CA2-DW1

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Vol Extracted: 900. ml
Extract Vol: 1.00 ml

Lab Sample ID: 98-A90060
Date Sampled:: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 7/98
Analysis Time: 15:58
Sample QC Group: 2293

Extraction Date: 8/ 4/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	20	.... U
83-32-9	Acenaphthene	20	.... U
120-12-7	Anthracene	7.33	.... U
206-44-0	Fluoranthene	2.33	.... U
7782-41-4	Fluorene	2.33	.... U
129-00-0	Pyrene	3	.... U
56-55-3	Benzo(a)anthracene	0.14	.... U
50-32-8	Benzo(a)pyrene	0.26	.... U
205-99-2	Benzo(b)fluoranthene	0.2	.... U
207-08-9	Benzo(k)fluoranthene	0.19	.... U
218-01-9	Chrysene	1.67	.... U
53-70-3	Dibenzo(a,h)anthracene	0.33	.... U
193-39-5	Indeno(1,2,3-cd)pyrene	0.48	.... U
208-96-8	Acenaphthylene	25.6	.... U
191-24-2	Benzo(g,h,i)perylene	0.84	.... U
85-01-8	Phenanthrene	7.11	.... U

000017

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-DUP1**

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-A90061
Date Sampled:: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 5/98
Analysis Time: 1:47
Sample QC Group: 1659

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	2.0	U
108-90-7	Chlorobenzene	2.0	U
95-50-1	1,2-Dichlorobenzene	4.0	U
541-73-1	1,3-Dichlorobenzene	4.0	U
106-46-7	1,4-Dichlorobenzene	3.0	U
100-41-4	Ethylbenzene	2.0	U
108-88-3	Toluene	2.0	U
108-38-3	m, p-Xylenes	2.0	U
95-47-6	o-Xylene	2.0	U
1634-04-4	MTBE	2.0	U

000018

SPECIALIZED ASSAYS, INC.

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CA2-DUP1

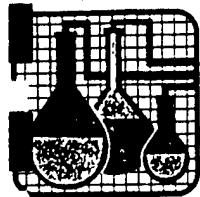
Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Vol Extracted: 910. ml
Extract Vol: 1.00 ml

Lab Sample ID: 98-A90061
Date Sampled:: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 7/98
Analysis Time: 16:35
Sample QC Group: 2293
Extraction Date: 8/ 4/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
	Naphthalene	19.8	U
83-32-9	Acenaphthene	19.8	U
120-12-7	Anthracene	7.25	U
206-44-0	Fluoranthene	2.31	U
7782-41-4	Fluorene	2.31	U
129-00-0	Pyrene	2.97	U
56-55-3	Benzo(a)anthracene	0.14	U
50-32-8	Benzo(a)pyrene	0.25	U
205-99-2	Benzo(b)fluoranthene	0.2	U
207-08-9	Benzo(k)fluoranthene	0.19	U
218-01-9	Chrysene	1.65	U
53-70-3	Dibenzo(a,h)anthracene	0.33	U
193-39-5	Indeno(1,2,3-cd)pyrene	0.47	U
208-96-8	Acenaphthylene	25.3	U
191-24-2	Benzo(g,h,i)perylene	0.84	U
85-01-8	Phenanthrene	7.03	U

000019

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-EQPBLK**

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-A90062
Date Sampled:: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 5/98
Analysis Time: 3:00
Sample QC Group: 1659

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	2.0	U
108-90-7	Chlorobenzene	2.0	U
95-50-1	1,2-Dichlorobenzene	4.0	U
541-73-1	1,3-Dichlorobenzene	4.0	U
106-46-7	1,4-Dichlorobenzene	3.0	U
100-41-4	Ethylbenzene	2.0	U
108-88-3	Toluene	2.0	U
108-38-3	m, p-Xylenes	2.0	U
95-47-6	o-Xylene	2.0	U
1634-04-4	MTBE	2.0	U

000020



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2960 Foster Creighton Dr.
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Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

TRIP BLANK

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-A90063
Date Sampled:
Date Received: 7/31/98
Analysis Date: 8/ 5/98
Analysis Time: 3:36
Sample QC Group: 1659

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	2.0	U
108-90-7	Chlorobenzene	2.0	U
95-50-1	1,2-Dichlorobenzene	4.0	U
541-73-1	1,3-Dichlorobenzene	4.0	U
106-46-7	1,4-Dichlorobenzene	3.0	U
100-41-4	Ethylbenzene	2.0	U
108-88-3	Toluene	2.0	U
108-38-3	m,p-Xylenes	2.0	U
95-47-6	o-Xylene	2.0	U
1634-04-4	MTBE	2.0	U

000021



SPECIALIZED ASSAYS, INC.

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Phone 1-615-726-0177

Sample Identification

CA2-SBEQPBLK

Matrix: Water
pH:
Units: ug/l
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001E

Lab Sample ID: 98-A90065
Date Sampled:: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 5/98
Analysis Time: 5:26
Sample QC Group: 1659

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	2.0	U
108-90-7	Chlorobenzene	2.0	U
95-50-1	1,2-Dichlorobenzene	4.0	U
541-73-1	1,3-Dichlorobenzene	4.0	U
106-46-7	1,4-Dichlorobenzene	3.0	U
100-41-4	Ethylbenzene	2.0	U
108-88-3	Toluene	2.0	U
108-38-3	m,p-Xylenes	2.0	U
95-47-6	o-Xylene	2.0	U
1634-04-4	MTBE	2.0	U

000024



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2960 Foster Creighton Dr.
P.O. Box 40566
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Phone 1-615-726-0177

Sample Identification

CA2-SB1-6

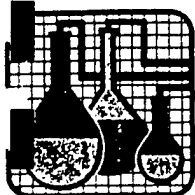
Matrix: Soil
% Dry Weight: 96.
Units: ug/kg dry weight
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90102
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 2/98
Analysis Time: 17:55
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	1.0	U 33
108-90-7	Chlorobenzene	2.1	U 33
95-50-1	1,2-Dichlorobenzene	4.2	U 33
541-73-1	1,3-Dichlorobenzene	4.2	U 33
106-46-7	1,4-Dichlorobenzene	3.1	U 33
100-41-4	Ethylbenzene	53.6	U 33
108-88-3	Toluene	12.1	U 33
108-38-3	m,p-Xylenes	61.8	U 33
95-47-6	o-Xylene	25.0	U 33
1634-04-4	MTBE	2.1	U 33

000025

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CAZ-SB1-6**

Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 50.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90102
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 2:10
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	50.0	U
108-90-7	Chlorobenzene	100.	U
95-50-1	1,2-Dichlorobenzene	200.	U
541-73-1	1,3-Dichlorobenzene	200.	U
106-46-7	1,4-Dichlorobenzene	150.	U
100-41-4	Ethylbenzene	140.	
108-88-3	Toluene	100.	U
108-38-3	m,p-Xylenes	165.	
95-47-6	o-Xylene	65.0	J
1634-04-4	MTBE	100.	U

000026



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2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CA2-SB1-6

Matrix: Soil
% Dry Weight: 96.
Units: ug/kg dry weight
Dilution Factor: 40.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90102
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 10:58
Sample QC Group: 1667
Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	50000	U
.....	Acenaphthene	50000	U
.....	Anthracene	18300	U
.....	Fluoranthene	5830	U
.....	Fluorene	5830	U
.....	Pyrene	1570	J
.....	Benzo(a)anthracene	764	U
.....	Benzo(a)pyrene	625	U
.....	Benzo(b)fluoranthene	500	U
.....	Benzo(k)fluoranthene	458	U
.....	Chrysene	5580	U
.....	Dibenzo(a,h)anthracene	833	U
.....	Indeno(1,2,3-cd)pyrene	1250	U
.....	Acenaphthylene	64200	U
.....	Benzo(g,h,i)perylene	2080	U
.....	Phenanthrene	17500	U

000027

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**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-EB2-6**

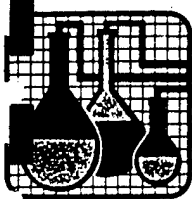
Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 50.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90103
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 2:47
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	50.0	U
108-90-7	Chlorobenzene	100.	U
95-50-1	1,2-Dichlorobenzene	200.	U
541-73-1	1,3-Dichlorobenzene	200.	U
106-46-7	1,4-Dichlorobenzene	150.	U
100-41-4	Ethylbenzene	170.	U
108-88-3	Toluene	100.	U
108-38-3	m,p-Xylenes	160.	U
95-47-6	o-Xylene	75.0	J
1634-04-4	MTBE	100.	U

000029

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-SB2-6**

Matrix: Soil
% Dry Weight: 96.
Units: ug/kg dry weight
Dilution Factor: 40.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90103
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 11:35
Sample QC Group: 1667

Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	50000	U
.....	Acenaphthene	50000	U
.....	Anthracene	18300	U
.....	Fluoranthene	2260	J
.....	Fluorene	5830	U
.....	Pyrene	7500	U
.....	Benzo(a)anthracene	611	
.....	Benzo(a)pyrene	625	U
.....	Benzo(b)fluoranthene	500	U
.....	Benzo(k)fluoranthene	458	U
.....	Chrysene	3950	J
.....	Dibenzo(a,h)anthracene	833	U
.....	Indeno(1,2,3-cd)pyrene	1250	U
.....	Acenaphthylene	64200	U
.....	Benzo(g,h,i)perylene	2080	U
.....	Phenanthrene	17500	U

000030

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-SB3-6**

Matrix: Soil
% Dry Weight: 91.
Units: ug/kg dry weight
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90104
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 2/98
Analysis Time: 19:08
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	1.1	U 55
108-90-7	Chlorobenzene	2.2	U 55
95-50-1	1,2-Dichlorobenzene	4.4	U 55
541-73-1	1,3-Dichlorobenzene	4.4	U 55
106-46-7	1,4-Dichlorobenzene	3.3	U 55
100-41-4	Ethylbenzene	16.2	U 55
108-88-3	Toluene	7.0	U 55
108-38-3	m,p-Xylenes	110.	U 55
95-47-6	o-Xylene	66.8	U 55
1634-04-4	MTBE	2.2	U 55

000031



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2960 Foster Creighton Dr.
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Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CA2-SB3-6

Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 50.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90104
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 3:23
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	50.0	U
108-90-7	Chlorobenzene	100.	U
95-50-1	1,2-Dichlorobenzene	200.	U
541-73-1	1,3-Dichlorobenzene	200.	U
106-46-7	1,4-Dichlorobenzene	150.	U
100-41-4	Ethylbenzene	100.	U
108-88-3	Toluene	100.	U
108-38-3	m,p-Xylenes	345.	
95-47-6	o-Xylene	255.	
1634-04-4	MTBE	100.	U

000032

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-SB3-6**

Matrix: Soil
% Dry Weight: 91.
Units: ug/kg dry weight
Dilution Factor: 40.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90104
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 12:49
Sample QC Group: 1667

Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	52700	U
.....	Acenaphthene	52700	U
.....	Anthracene	19300	U
.....	Fluoranthene	6150	U
.....	Fluorene	6150	U
.....	Pyrene	7910	U
.....	Benzo(a)anthracene	1480	
.....	Benzo(a)pyrene	176	J
.....	Benzo(b)fluoranthene	527	U
.....	Benzo(k)fluoranthene	484	U
.....	Chrysene	1130	J
.....	Dibenzo(a,h)anthracene	879	U
.....	Indeno(1,2,3-cd)pyrene	1320	U
.....	Acenaphthylene	67700	U
.....	Benzo(g,h,i)perylene	2200	U
.....	Phenanthrene	18500	U

000033

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-SB4-6**

Matrix: Soil
% Dry Weight: 86.
Units: ug/kg dry weight
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90105
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 2/98
Analysis Time: 19:45
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	2.8	U
108-90-7	Chlorobenzene	2.3	U
95-50-1	1,2-Dichlorobenzene	4.7	U
541-73-1	1,3-Dichlorobenzene	4.7	U
106-46-7	1,4-Dichlorobenzene	3.5	U
100-41-4	Ethylbenzene	96.6	U
108-88-3	Toluene	62.0	U
108-38-3	m,p-Xylenes	132.	U
95-47-6	o-Xylene	39.8	U
1634-04-4	MTBE	2.3	U

000034

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-SB4-6**

Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 50.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90105
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 4:00
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	50.0	U
108-90-7	Chlorobenzene	100.	U
95-50-1	1,2-Dichlorobenzene	200.	U
541-73-1	1,3-Dichlorobenzene	200.	U
106-46-7	1,4-Dichlorobenzene	150.	U
100-41-4	Ethylbenzene	370.	
108-88-3	Toluene	75.0	J
108-38-3	m,p-Xylenes	415.	
95-47-6	o-Xylene	180.	
1634-04-4	MTBE	100.	U

000035



SPECIALIZED ASSAYS, INC.

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CA2-SB4-6

Matrix: Soil
% Dry Weight: 86.
Units: ug/kg dry weight
Dilution Factor: 40.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90105
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 13:26
Sample QC Group: 1667
Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	55800	U
.....	Acenaphthene	55800	U
.....	Fluorene	6510	U
.....	Acenaphthylene	71600	U

000036

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-SB4-6**

Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 200.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90105
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 19:34
Sample QC Group: 1667

Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	240000.....	U
.....	Acenaphthene	240000.....	U
.....	Anthracene	88000	U
.....	Fluoranthene	9270	J
.....	Fluorene	28000	U
.....	Pyrene	36000	U
.....	Benzo(a)anthracene	3000	
.....	Benzo(a)pyrene	3000	U
.....	Benzo(b)fluoranthene	2400	U
.....	Benzo(k)fluoranthene	2200	U
.....	Chrysene	20000	U
.....	Dibenzo(a,h)anthracene	4000	U
.....	Indeno(1,2,3-cd)pyrene	6000	U
.....	Acenaphthylene	308000.....	U
.....	Benzo(g,h,i)perylene	10000	U
.....	Phenanthrene	84000	U

000037

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification**CA2-SB5-6**

Matrix: Soil
% Dry Weight: 87.
Units: ug/kg dry weight
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90106
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 2/98
Analysis Time: 20:21
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	1.1	U U5
108-90-7	Chlorobenzene	2.3	U U5
95-50-1	1,2-Dichlorobenzene	4.6	U U5
541-73-1	1,3-Dichlorobenzene	4.6	U U5
106-46-7	1,4-Dichlorobenzene	3.4	U U5
100-41-4	Ethylbenzene	61.7	U U5
108-88-3	Toluene	9.3	U U5
108-38-3	m,p-Xylenes	35.5	U U5
95-47-6	o-Xylene	26.8	U U5
1634-04-4	MTBE	2.3	U U5

000038



SPECIALIZED ASSAYS, INC.

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CA2-SB5-6

Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 50.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90106
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 4:36
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	50.0	U
108-90-7	Chlorobenzene	100.	U
95-50-1	1,2-Dichlorobenzene	200.	U
541-73-1	1,3-Dichlorobenzene	200.	U
106-46-7	1,4-Dichlorobenzene	150.	U
100-41-4	Ethylbenzene	105.	
108-88-3	Toluene	100.	U
108-38-3	m,p-Xylenes	65.0	J
95-47-6	o-Xylene	100.	U
1634-04-4	MTBE	100.	U

SPECIALIZED ASSAYS, INC.

2960 Foster Creighton Dr.
P.O. Box 40566
Nashville, TN 37204-0566
Phone 1-615-726-0177

Sample Identification

CA2-SB5-6

Matrix: Soil
% Dry Weight: 87.
Units: ug/kg dry weight
Dilution Factor: 40.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90106
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 14:02
Sample QC Group: 1667
Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	55200	U
.....	Acenaphthene	55200	U
.....	Anthracene	20200	U
.....	Fluorene	6440	U
.....	Acenaphthylene	70800	U
.....	Phenanthrene	19300	U

000040

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2960 Foster Creighton Dr.
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Sample Identification

CA2-SB5-6

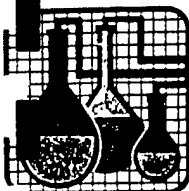
Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 200.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90106
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 20:11
Sample QC Group: 1667
Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	240000....	U
.....	Acenaphthene	240000....	U
.....	Anthracene	88000	U
.....	Fluoranthene	6270	J
.....	Fluorene	28000	U
.....	Pyrene	36000	U
.....	Benzo(a)anthracene	1200	J
.....	Benzo(a)pyrene	1400	J
.....	Benzo(b)fluoranthene	2400	U
.....	Benzo(k)fluoranthene	2200	U
.....	Chrysene	20000	U
.....	Dibenzo(a,h)anthracene	4000	U
.....	Indeno(1,2,3-cd)pyrene	6000	U
.....	Acenaphthylene	308000....	U
.....	Benzo(g,h,i)perylene	10000	U
.....	Phenanthrene	84000	U

000041



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Sample Identification

CA2-SB6-6

Matrix: Soil
% Dry Weight: 95.
Units: ug/kg dry weight
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90107
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/2/98
Analysis Time: 20:58
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	1.1	U WS
108-90-7	Chlorobenzene	2.1	U WS
95-50-1	1,2-Dichlorobenzene	4.2	U WS
541-73-1	1,3-Dichlorobenzene	4.2	U WS
106-46-7	1,4-Dichlorobenzene	3.2	U WS
100-41-4	Ethylbenzene	113.	U WS
108-88-3	Toluene	14.4	U WS
108-38-3	m,p-Xylenes	151.	U WS
95-47-6	o-Xylene	43.9	U WS
1634-04-4	MTBE	2.1	U WS

000042



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Sample Identification

CA2-SB6-6

Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 50.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90107
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 5:13
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	50.0	U
108-90-7	Chlorobenzene	100.	U
95-50-1	1,2-Dichlorobenzene	200.	U
541-73-1	1,3-Dichlorobenzene	200.	U
106-46-7	1,4-Dichlorobenzene	150.	U
100-41-4	Ethylbenzene	295.	
108-88-3	Toluene	100.	U
108-38-3	m,p-Xylenes	490.	
95-47-6	o-Xylene	105.	
1634-04-4	MTBE	100.	U

000043

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Phone 1-615-726-0177

Sample Identification

CA2-SB6-6

Matrix: Soil
% Dry Weight: 95.
Units: ug/kg dry weight
Dilution Factor: 40.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90107
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 16:30
Sample QC Group: 1667
Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
	Naphthalene	50500	U
	Acenaphthene	50500	U
	Anthracene	18500	U
	Fluoranthene	3650	J
	Fluorene	1400	J
	Pyrene	7580	U
	Benzo(a)anthracene	702	
	Benzo(a)pyrene	632	U
	Benzo(b)fluoranthene	505	U
	Benzo(k)fluoranthene	463	U
	Chrysene	4210	U
	Dibenzo(a,h)anthracene	842	U
	Indeno(1,2,3-cd)pyrene	1260	U
	Acenaphthylene	64800	U
	Benzo(g,h,i)perylene	2110	U
	Phenanthrene	17700	U

**SPECIALIZED ASSAYS, INC.**

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Sample Identification**CA2-SB7-6**

Matrix: Soil
% Dry Weight: 83.
Units: ug/kg dry weight
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90108
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 2/98
Analysis Time: 21:34
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	1.2	U
108-90-7	Chlorobenzene	2.4	U
95-50-1	1,2-Dichlorobenzene	4.8	U
541-73-1	1,3-Dichlorobenzene	4.8	U
106-46-7	1,4-Dichlorobenzene	3.6	U
100-41-4	Ethylbenzene	12.2	
108-88-3	Toluene	2.3	✓
108-38-3	m,p-Xylenes	39.5	
95-47-6	o-Xylene	26.0	
1634-04-4	MTBE	2.4	U

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Sample Identification

CA2-SB7-6

Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 50.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90108
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 5:50
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	50.0	U
108-90-7	Chlorobenzene	100.	U
95-50-1	1,2-Dichlorobenzene	200.	U
541-73-1	1,3-Dichlorobenzene	200.	U
106-46-7	1,4-Dichlorobenzene	150.	U
100-41-4	Ethylbenzene	100.	U
108-88-3	Toluene	100.	U
108-38-3	m,p-Xylenes	100.	U
95-47-6	o-Xylene	100.	U
1634-04-4	MTBE	100.	U

000046

**SPECIALIZED ASSAYS, INC.**

2960 Foster Creighton Dr.
P.O. Box 40566
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Phone 1-615-726-0177

Sample Identification**CA2-SB7-6**

Matrix: Soil
% Dry Weight: 83.
Units: ug/kg dry weight
Dilution Factor: 40.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

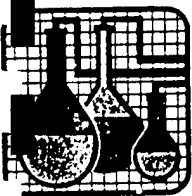
Lab Sample ID: 98-90108
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 14:39
Sample QC Group: 1667

Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	57800	U
.....	Acenaphthene	57800	U
.....	Anthracene	21200	U
.....	Fluoranthene	2890	J
.....	Fluorene	6750	U
.....	Pyrene	8670	U
.....	Benzo(a)anthracene	980	
.....	Benzo(a)pyrene	723	U
.....	Benzo(b)fluoranthene	578	U
.....	Benzo(k)fluoranthene	530	U
.....	Chrysene	964	J
.....	Dibenzo(a,h)anthracene	964	U
.....	Indeno(1,2,3-cd)pyrene	1450	U
.....	Acenaphthylene	74200	U
.....	Benzo(g,h,i)perylene	2410	U
.....	Phenanthrene	20200	U

000047



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Sample Identification

CA2-SB8-6

Matrix: Soil
% Dry Weight: 75.
Units: ug/kg dry weight
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90109
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 2/98
Analysis Time: 22:47
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	1.3	U
108-90-7	Chlorobenzene	2.7	U
95-50-1	1,2-Dichlorobenzene	5.3	U
541-73-1	1,3-Dichlorobenzene	5.3	U
106-46-7	1,4-Dichlorobenzene	4.0	U
100-41-4	Ethylbenzene	46.8	
108-88-3	Toluene	18.9	
108-38-3	m,p-Xylenes	66.5	
95-47-6	o-Xylene	22.7	
1634-04-4	MTBE	2.7	U

000048



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Sample Identification

CA2-SB8-6

Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 50.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90109
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 6:26
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	50.0	U
108-90-7	Chlorobenzene	100.	U
95-50-1	1,2-Dichlorobenzene	200.	U
541-73-1	1,3-Dichlorobenzene	200.	U
106-46-7	1,4-Dichlorobenzene	150.	U
100-41-4	Ethylbenzene	65.0	J
108-88-3	Toluene	100.	U
108-38-3	m,p-Xylenes	90.0	J
95-47-6	o-Xylene	100.	U
1634-04-4	MTBE	100.	U

000049



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Sample Identification

CA2-SB8-6

Matrix: Soil
% Dry Weight: 75.
Units: ug/kg dry weight
Dilution Factor: 40.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90109
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 17:07
Sample QC Group: 1667
Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	64000	U
.....	Acenaphthene	64000	U
.....	Anthracene	23500	U
.....	Fluoranthene	4730	J
.....	Fluorene	7470	U
.....	Pyrene	9600	U
.....	Benzo(a)anthracene	1710	
.....	Benzo(a)pyrene	231	J
.....	Benzo(b)fluoranthene	640	U
.....	Benzo(k)fluoranthene	587	U
.....	Chrysene	1640	J
.....	Dibenzo(a,h)anthracene	1070	U
.....	Indeno(1,2,3-cd)pyrene	1600	U
.....	Acenaphthylene	82100	U
.....	Benzo(g,h,i)perylene	2670	U
.....	Phenanthrene	22400	U

000050



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Sample Identification

CA2-SB9-6

Matrix: Soil
% Dry Weight: 84.
Units: ug/kg dry weight
Dilution Factor: 1.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90110
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 2/98
Analysis Time: 23:24
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	1.2	U
108-90-7	Chlorobenzene	2.4	U
95-50-1	1,2-Dichlorobenzene	4.8	U
541-73-1	1,3-Dichlorobenzene	4.8	U
106-46-7	1,4-Dichlorobenzene	3.6	U
100-41-4	Ethylbenzene	2.4	U
108-88-3	Toluene	2.4	U
108-38-3	m, p-Xylenes	2.4	U
95-47-6	o-Xylene	2.4	U
1634-04-4	MTBE	2.4	U

000051



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Sample Identification

CA2-SB9-6

Matrix: Soil
% Dry Weight: 84.
Units: ug/kg dry weight
Dilution Factor: 10.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90110
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 21:25
Sample QC Group: 1667

Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
	Naphthalene	14300	U
	Acenaphthene	14300	U
	Anthracene	5240	U
	Fluoranthene	1670	U
	Fluorene	1670	U
	Pyrene	2140	U
	Benzo(a)anthracene	214	
	Benzo(a)pyrene	95	J
	Benzo(b)fluoranthene	143	U
	Benzo(k)fluoranthene	131	U
	Chrysene	1190	U
	Dibenzo(a,h)anthracene	238	U
	Indeno(1,2,3-cd)pyrene	357	U
	Acenaphthylene	18300	U
	Benzo(g,h,i)perylene	595	U
	Phenanthrene	5000	U

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Sample Identification

CA2-DUP1-6

Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 50.
Analysis Method: SW8021B
Delivery Group: 108621
Instrument: T9001B

Lab Sample ID: 98-90111
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 4/98
Analysis Time: 7:03
Sample QC Group: 1660

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
71-43-2	Benzene	50.0	U
108-90-7	Chlorobenzene	100.	U
95-50-1	1,2-Dichlorobenzene	200.	U
541-73-1	1,3-Dichlorobenzene	200.	U
106-46-7	1,4-Dichlorobenzene	150.	U
100-41-4	Ethylbenzene	265.	
108-88-3	Toluene	55.0	J
108-38-3	m,p-Xylenes	320.	
95-47-6	o-Xylene	160.	
1634-04-4	MTBE	100.	U

000054



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Sample Identification

CA2-DUP1-6

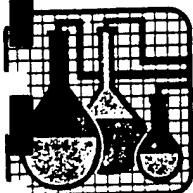
Matrix: Soil
% Dry Weight: 83.
Units: ug/kg dry weight
Dilution Factor: 40.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90111
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 15:16
Sample QC Group: 1667
Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	57800	U
.....	Acenaphthene	57800	U
.....	Fluorene	2110	J
.....	Acenaphthylene	74200	U

000055



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Sample Identification

CA2-DUP1-6

Matrix: Soil
% Dry Weight:
Units: ug/kg
Dilution Factor: 200.
Analysis Method: SW8310
Delivery Group: 108621
Instrument:
Grams Extracted: 30.0 g
Extract Vol: 1.00 ml

Lab Sample ID: 98-90111
Date Sampled: 7/30/98
Date Received: 7/31/98
Analysis Date: 8/ 9/98
Analysis Time: 20:48
Sample QC Group: 1667

Extraction Date: 8/ 5/98

FORM I

CAS NUMBER	ANALYTE	CONCENTRATION	FLAG
.....	Naphthalene	240000.....	U
.....	Acenaphthene	240000.....	U
.....	Anthracene	88000	U
.....	Fluoranthene	7470	J
.....	Fluorene	28000	U
.....	Pyrene	36000	U
.....	Benzo(a)anthracene	2200	
.....	Benzo(a)pyrene	3000	U
.....	Benzo(b)fluoranthene	2400	U
.....	Benzo(k)fluoranthene	2200	U
.....	Chrysene	20000	U
.....	Dibenzo(a,h)anthracene	4000	U
.....	Indeno(1,2,3-cd)pyrene	6000	U
.....	Acenaphthylene	308000.....	U
.....	Benzo(g,h,i)perylene	10000	U
.....	Phenanthrene	84000	U

000056



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FLA PRO RESULTS SUMMARY

FORM I

LAB ID	Sample ID	FLA PRO CONCENTRATION (ug/L)	Flag
98-A90056	CA2-MW2	210	U
98-A90057	CA2-MW6	210	U
98-A90058	CA2-MW7	220	U
98-A90059	CA2-MW9	210	U
98-A90060	CA2-DW1	210	U
98-A90061	CA2-DUP2	210	U
98-A90064	CA2-MW1	22100 J	

000637



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FLA PRO RESULTS SUMMARY

FORM I

LAB ID	Sample ID	FLA PRO CONCENTRATION (mg/Kg dry wght)	Flag	% DRY WGHT
98-A90102	CA2-SB1-6	10729		96
98-A90103	CA2-SB2-6	6229		96
98-A90104	CA2-SB3-6	9780		91
98-A90105	CA2-SB4-6	12674		86
98-A90106	CA2-SB5-6	5092		87
98-A90107	CA2-SB6-6	3411		95
98-A90108	CA2-SB7-6	3012		83
98-A90109	CA2-SB8-6	2173	5	75
98-A90110	CA2-SB9-6	444		84
98-A90111	CA2-DUP1-6 CA2-SB9-6 ID	11458		83

000736



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FLA PRO RESULTS SUMMARY

FORM I

LAB ID	Sample ID	FLA PRO CONCENTRATION (mg/Kg dry wght)	Flag	% DRY WGHT
98-A90102	CA2-SB1-6	10729		96
98-A90103	CA2-SB2-6	6229		96
98-A90104	CA2-SB3-6	9780		91
98-A90105	CA2-SB4-6	12674		86
98-A90106	CA2-SB5-6	5092		87
98-A90107	CA2-SB6-6	3411		95
98-A90108	CA2-SB7-6	3012		83
98-A90109	CA2-SB8-6	2173		75
98-A90110	CA2-SB9-6	444		84
98-A90111	CA2-DUP1-6	11458		83

000736

Date of Analysis: 8/12/98 Date Collected: 7/29/98 - 7/30/98

APPENDIX D
DATA QUALITY ASSESSMENT REPORT

APPENDIX D

DATA QUALITY ASSESMENT REPORT FACILITY 1748, SWMU 134 CAPE CANAVERAL AIR STATION, FLORIDA

D1.0 INTRODUCTION

A Parsons Engineering Science electronic Level III validation was performed for Cape Canaveral Air Station (AS) and consisted of electronically and manually examining data deliverables to determine data quality. This included application of data qualifiers to the analytical results based on adherence to method protocols and project-specific quality assurance/quality control (QA/QC) limits. Method protocols reviewed included:

- analytical holding times,
- method blanks (MB),
- trip blanks (TB),
- surrogate spikes,
- matrix spikes/matrix spike duplicates (MS/MSDs),
- laboratory control samples (LCSs), and
- shipping cooler temperature.

Data qualifiers were applied to analytical results during the data validation process. All data were validated using method applicable guidelines and in accordance with the *National Functional Guidelines for Organic Data Review* (USEPA, 1994a) and the *National Functional Guidelines for Inorganic Data Review* (USEPA, 1994b).

The following definitions provide explanations of the USEPA (1994a and 1994b) qualifiers assigned to analytical results during data validation. The data qualifiers described were applied to both inorganic and organic results.

- U - The analyte was analyzed for and is not present above the reported sample quantitation limit (SQL).
- J - The analyte was analyzed for and was positively identified, but the associated numerical value may not be consistent with the amount actually present in the environmental sample. The data should be considered as a basis for decision-making and are usable for many purposes.

- R - The data are rejected as unusable for all purposes. The analyte was analyzed for, but the presence or absence of the analyte was not verified. Resampling and reanalysis are necessary to confirm the presence or absence of the analyte.
- UJ - The analyte analyzed for was not present above the reported SQL. The associated numerical value may not accurately or precisely represent the concentration necessary to detect the analyte in the sample.
- J1 The analyte is qualified as an estimated value solely because it is greater than the method detection limit (MDL) and less than the PQL indicating no laboratory quality issues.

D2.0 DATA QUALITY

Data quality for each QC parameter where exceptions were noted during the validation is summarized in this section. Only results that exceeded QA/QC criteria are presented. All frequency requirements for field sample collection of QA/QC samples (MS/MSDs and blanks) were met. The frequency requirements for laboratory specific method criteria QA/QC were met overall. In Attachment A, Tables A-1 and A-2 present the analytical methods performed for each samples and the samples that were qualified during the validation process, respectively.

D2.1 Surrogate Spikes

Table D2.1-1 lists all results for target analytes that are out of control with the percentage of out of control results calculated against the total number of samples collected. Methods SW8021B and FLAPRO displayed surrogate recovery problems. For FLAPRO, the surrogate recoveries on two samples were high, 140 and 120 percent, indicating a high bias in the sample results. For SW8021B, the surrogate recoveries were low on the undiluted samples indicating a low bias in the sample results. The results were qualified as estimated. The SW8021B samples were diluted and reanalyzed resulting in acceptable surrogate recoveries but higher reporting limits for the nondetected compounds. The undiluted samples, although qualified as estimated, are still usable for the purposes intended. The final reported values for SW8021B in the main text of this report are selected from both analytical runs (diluted and undiluted) and represent the lowest reporting limit for nondetects and the highest concentration for detects, regardless of qualification. Out-of-control surrogate recovery results that did not meet control criteria are believed to be caused by matrix interference.

D2.2 Matrix Spikes/Matrix Spike Duplicates

MS/MSD validation flags were applied only to the parent sample from a non-compliant MS/MSD. Sample results were not qualified on an analytical batch basis. Table D2.2-1 lists all results for target compounds that are out of control with the

TABLE D2.1-1
OUT-OF-CONTROL SURROGATE SPIKE IMPACT
 FACILITY 1748, SWMU 134
 CAPE CANAVERAL AS, FLORIDA

Anal. Method	Prep. Method	Matrix	Analyte	Flag	# of Qualified Results	Total Number of Samples	Percent of Results Qualified
SW8021	SW5030	SO	1,2-Dichlorobenzene	UJ	8	10	80%
SW8021	SW5030	SO	1,3-Dichlorobenzene	UJ	8	10	80%
SW8021	SW5030	SO	1,4-Dichlorobenzene	UJ	8	10	80%
SW8021	SW5030	SO	Benzene	J	2	10	20%
SW8021	SW5030	SO	Benzene	UJ	6	10	60%
SW8021	SW5030	SO	Chlorobenzene	UJ	8	10	80%
SW8021	SW5030	SO	Ethylbenzene	J	8	10	80%
SW8021	SW5030	SO	m,p-Xylenes	J	8	10	80%
SW8021	SW5030	SO	MTBE	UJ	8	10	80%
SW8021	SW5030	SO	o-Xylene	J	8	10	80%
SW8021	SW5030	SO	Toluene	J	8	10	80%
FLAPRO	SW3550	SO	TRPH	J	1	10	10%
FLAPRO	SW3510	WG	TRPH	J	1	8	12%

percentage of out-of-control results calculated against the total number of samples collected. Out-of-control analytical results are believed to be related to matrix interference. The spike recovery for toluene indicates a low bias. Recoveries that did not meet control criteria are believed to result from matrix interference.

TABLE D2.2-1
OUT-OF-CONTROL MS/MSD IMPACT
 FACILITY 1748, SWMU 134
 CAPE CANAVERAL AS, FLORIDA

Anal. Method	Prep. Method	Matrix	Analyte	Flag	# of Qualified Results	Total Number of Samples	Percent of Results Qualified
SW8021	SW5030	SO	Toluene	J<	1	10	10%
SW8021	SW5030	SO	Toluene	UJ<	1	10	10%

D2.3 Field Duplicates

Table D2.3-1 lists the field duplicate results for compounds where at least one sample in the duplicate pair was detected. The relative percent difference (RPD) for benzene is 73% but the sample results are near the reporting limit. The fluorene duplicate result is less than the reporting limit. The data is not qualified based on field duplicate results.

TABLE D2.3-1
FIELD DUPLICATES
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

Location	Matrix	SBD	SED	Anal. Method	Prep. Method	Sample Result	Sample Dup Result	RPD	Units	Analyte
CA2-SB4	SO	5.7	6.2	SW8310	SW3550	3000	2200	31%	UG/KG	Benzo(a)anthracene
CA2-SB4	SO	5.7	6.2	SW8310	SW3550	0	2110	200%	UG/KG	Fluorene
CA2-SB4	SO	5.7	6.2	SW8021	SW5030	2.8	1.3	73%	UG/KG	Benzene
CA2-SB4	SO	5.7	6.2	SW8021	SW5030	96.6	91.2	6%	UG/KG	Ethylbenzene
CA2-SB4	SO	5.7	6.2	SW8021	SW5030	62.0	44.8	32%	UG/KG	Toluene
CA2-SB4	SO	5.7	6.2	SW8021	SW5030	132	122	8%	UG/KG	m,p-Xylenes
CA2-SB4	SO	5.7	6.2	SW8021	SW5030	39.8	35.9	10%	UG/KG	o-Xylene
CA2-SB4	SO	5.7	6.2	SW8310	SW3550	9270	7470	22%	UG/KG	Fluoranthene
CA2-SB4	SO	5.7	6.2	FLAPRO	SW3550	12674	11458	10%	UG/KG	TRPH
CA2-DW1	WG	0	0	SW9056	NONE	9.2	9.3	1%	MG/KG	Sulfate

D3.0 CONCLUSIONS

Samples were collected and analyzed as specified in the methods with exception of those issues discussed in this report. All samples are representative of the site and comparable with previous and future investigations (when used in accordance with the validation qualifiers). All sample results qualified as "UJ or J" represent an association to non-compliant QC criteria that has caused the reported concentration to be estimated. Project objectives do not exclude the use of estimated concentrations. No data was rejected based on the validation, therefore completeness goals of 90 percent were met. Therefore, all data are usable for the purposes intended.

D4.0 REFERENCES

- U.S. Environmental Protection Agency (USEPA). 1983. Methods for the Chemical Analysis of Water and Wastes. EPA 600/4-79-020. Cincinnati, OH.
- USEPA. 1993. Data Quality Objectives Process for Superfund. EPA 540-R-93-071. Washington, DC. September, 1993.
- USEPA. 1987-1996. SW-846, Test Methods for Evaluating Solid Waste, Physical and Chemical Methods, Third Edition. Washington, DC.
- USEPA. 1994a. Agency National Functional Guidelines for Organic Data Review. PB 94-963502. Washington, DC.
- USEPA. 1994b. Agency National Functional Guidelines for Inorganic Data Review. PB 94-963501. Washington, DC.

ATTACHMENT A

**VALIDATED SAMPLES AND QUALIFIED ANALYTICAL
RESULTS**

VALIDATED SAMPLES AND QUALIFIED ANALYTICAL RESULTS

Tables A-1 and A-2 list all qualified sample data based on the results of data validation. The following definitions of column headers will aide in the understanding and use of these tables.

LOCID:	Sample location identifier, unique to each sample when used in conjunction of columns SBD and SED.
MX:	Sample matrix identifier. "SO" is soil, "WG" is water.
SA:	Sample analysis identifier. "N" is for primary field samples, "FR" is for field replicate samples. "N1" or "FR1" designates that the results associated to the original sample analysis. "N8" or "FR8" designates that the results associated to a composite of sample analysis results.
SBD:	Sample beginning depth.
SED:	Sample ending depth.
COMPOUND NAME:	This column identifies the target compound name.
VQ:	This column designates if a target compound was detected or not. An "=" denotes a detection above the project practical quantitation limit. A "ND" denotes a non-detection above the method detection limit. A "TR" denotes a detection above the method detection limit but below the project practical quantitation limit.
PARVAL:	This is the concentration of detection for all detected sample results (TR or =). A zero is a placeholder, which associates to a non-detected compound. The zero does not imply that the compound was not detected at less than zero.
LABDL:	This is the concentration at which the laboratory reports the project reporting limit. The project reporting limit is a practical quantitation limit in that it is related to a multiplier of the method detection limit.
ANMCODE:	Analytical method code identifier.
EXMCODE:	Analytical extraction method code identifier.

Q: This column represents the final validation qualifier applied to the sample result. It is a composite of all the validation qualifiers for that sample result.

The following column headers apply to the method criteria that are included in a data validation. All of the columns may not appear in Table A-2. Only those method criteria that resulted in qualifying sample results are listed.

HTM	Holding Time
MBM	Method Blank
TBM	Trip Blanks
CBM	Calibration Blank
EBM	Equipment Blanks
ABM	Ambient Blanks
MSRM	MS/MSD (%Recovery/Accuracy)
MSPM	MS/MSD (%RPD/Precision)
LCRM	LCS (%Recovery/Accuracy)
LCPM	LCS (%RPD/Precision)
SURM	Surrogate
RAM	Linear Range
CCPM	Compound Confirmation Precision
CIDM	Compound Identification
ICLM	Initial Calibration
ICVM	Initial Calibration Verification
CCVM	Continuing Calibration
TUNM	GC/MS Tuning
IPM	Instrument Performance
ICSM	Interference Check Sample
LRM	Laboratory Duplicate
PDSM	Post Digestion Spike
MSAM	Method of Standard Additions
SDM	Serial Dilution
ISM	Internal Standard
TMPM	Temperature
PRSM	Preservation
3REP	% RSD for 3 ICP Burns
QNTM	Compound Quantitation

The following flags have been included with the validation qualifiers to help determine the magnitude of the exceeded criteria where possible.

- > Greater than upper control limit (CL)
- < Less than lower CL but greater than two times lower CL

TABLE A-1
ANALYTICAL METHODS BY SAMPLE LOCATION
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

LOCID	SBD	SED	MATRIX	SW8021	SW8310	FLAPRO	RSKSOP175	SW9056
CA2-DW1	0	0	WG	X	X	X		X
CA2-MW2	0	0	WG	X	X	X	X	X
CA2-MW6	0	0	WG	X	X	X		X
CA2-MW7	0	0	WG	X	X	X		X
CA2-MW9	0	0	WG	X	X	X		X
CA2-SB1	5.7	6.2	SO	X	X	X		
CA2-SB2	5.7	6.2	SO	X	X	X		
CA2-SB3	5.7	6.2	SO	X	X	X		
CA2-SB4	5.7	6.2	SO	X	X	X		
CA2-SB5	5.7	6.2	SO	X	X	X		
CA2-SB6	5.7	6.2	SO	X	X	X		
CA2-SB7	5.7	6.2	SO	X	X	X		
CA2-SB8	5.7	6.2	SO	X	X	X		
CA2-SB9	5.7	6.2	SO	X	X	X		
MW-1	0	0	WG	X	X	X		

TABLE A-2
QUALIFIED ANALYTICAL RESULTS
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

LOCID	SBD	SED	MATRIX	SA CODE	ANM CODE	EXM CODE	ANALYTE	PARVQ	PARVAL	LABDL	UNITS	FINAL	MSRM	SURM
CA2-SB1	5.7	6.2	SO	N1	SW8021	SW5030	1,2-Dichlorobenzene	ND	0	4.2	UG/KG	UJ		UJ
CA2-SB1	5.7	6.2	SO	N1	SW8021	SW5030	1,3-Dichlorobenzene	ND	0	4.2	UG/KG	UJ		UJ
CA2-SB1	5.7	6.2	SO	N1	SW8021	SW5030	1,4-Dichlorobenzene	ND	0	3.1	UG/KG	UJ		UJ
CA2-SB1	5.7	6.2	SO	N1	SW8021	SW5030	Benzene	ND	0	1	UG/KG	UJ		UJ
CA2-SB1	5.7	6.2	SO	N1	SW8021	SW5030	Chlorobenzene	ND	0	2.1	UG/KG	UJ		UJ
CA2-SB1	5.7	6.2	SO	N1	SW8021	SW5030	Ethylbenzene	=	53.6	2.1	UG/KG	J		J
CA2-SB1	5.7	6.2	SO	N1	SW8021	SW5030	m,p-Xylenes	=	61.8	2.1	UG/KG	J		J
CA2-SB1	5.7	6.2	SO	N1	SW8021	SW5030	MTBE	ND	0	2.1	UG/KG	UJ		UJ
CA2-SB1	5.7	6.2	SO	N1	SW8021	SW5030	o-Xylene	=	25	2.1	UG/KG	J		J
CA2-SB1	5.7	6.2	SO	N1	SW8021	SW5030	Toluene	=	12.1	2.1	UG/KG	J	J <	J
CA2-SB1	5.7	6.2	SO	N2	SW8021	SW5030	Toluene	ND	0	100	UG/KG	UJ	UJ <	
CA2-SB2	5.7	6.2	SO	N1	SW8021	SW5030	1,2-Dichlorobenzene	ND	0	4.2	UG/KG	UJ		UJ
CA2-SB2	5.7	6.2	SO	N1	SW8021	SW5030	1,3-Dichlorobenzene	ND	0	4.2	UG/KG	UJ		UJ
CA2-SB2	5.7	6.2	SO	N1	SW8021	SW5030	1,4-Dichlorobenzene	ND	0	3.1	UG/KG	UJ		UJ
CA2-SB2	5.7	6.2	SO	N1	SW8021	SW5030	Benzene	ND	0	1	UG/KG	UJ		UJ
CA2-SB2	5.7	6.2	SO	N1	SW8021	SW5030	Chlorobenzene	ND	0	2.1	UG/KG	UJ		UJ
CA2-SB2	5.7	6.2	SO	N1	SW8021	SW5030	Ethylbenzene	=	73.6	2.1	UG/KG	J		J
CA2-SB2	5.7	6.2	SO	N1	SW8021	SW5030	m,p-Xylenes	=	658	2.1	UG/KG	J		J
CA2-SB2	5.7	6.2	SO	N1	SW8021	SW5030	MTBE	ND	0	2.1	UG/KG	UJ		UJ
CA2-SB2	5.7	6.2	SO	N1	SW8021	SW5030	o-Xylene	=	29.5	2.1	UG/KG	J		J
CA2-SB2	5.7	6.2	SO	N1	SW8021	SW5030	Toluene	=	15.7	2.1	UG/KG	J		J
CA2-SB3	5.7	6.2	SO	N1	SW8021	SW5030	1,2-Dichlorobenzene	ND	0	4.4	UG/KG	UJ		UJ
CA2-SB3	5.7	6.2	SO	N1	SW8021	SW5030	1,3-Dichlorobenzene	ND	0	4.4	UG/KG	UJ		UJ

A-4

TABLE A-2 (Continued)
QUALIFIED ANALYTICAL RESULTS
FACILITY 1748, SWMU 134
CAPE CANAVERAL AS, FLORIDA

LOCID	SBD	SED	MATRIX	SA CODE	ANM CODE	EXM CODE	ANALYTE	PARVQ	PARVAL	LABDL	UNITS	FINAL Q	MSRM	SURM
CA2-SB3	5.7	6.2	SO	N1	SW8021	SW5030	1,4-Dichlorobenzene	ND	0	3.3	UG/KG	UJ		UJ
CA2-SB3	5.7	6.2	SO	N1	SW8021	SW5030	Benzene	ND	0	1.1	UG/KG	UJ		UJ
CA2-SB3	5.7	6.2	SO	N1	SW8021	SW5030	Chlorobenzene	ND	0	2.2	UG/KG	UJ		UJ
CA2-SB3	5.7	6.2	SO	N1	SW8021	SW5030	Ethylbenzene	=	16.2	2.2	UG/KG	J		J
CA2-SB3	5.7	6.2	SO	N1	SW8021	SW5030	m,p-Xylenes	=	110	2.2	UG/KG	J		J
CA2-SB3	5.7	6.2	SO	N1	SW8021	SW5030	MTBE	ND	0	2.2	UG/KG	UJ		UJ
CA2-SB3	5.7	6.2	SO	N1	SW8021	SW5030	o-Xylene	=	66.8	2.2	UG/KG	J		J
CA2-SB3	5.7	6.2	SO	N1	SW8021	SW5030	Toluene	=	7	2.2	UG/KG	J		J
CA2-SB4	5.7	6.2	SO	FR1	SW8021	SW5030	1,2-Dichlorobenzene	ND	0	4.8	UG/KG	UJ		UJ
CA2-SB4	5.7	6.2	SO	FR1	SW8021	SW5030	1,3-Dichlorobenzene	ND	0	4.8	UG/KG	UJ		UJ
CA2-SB4	5.7	6.2	SO	FR1	SW8021	SW5030	1,4-Dichlorobenzene	ND	0	3.6	UG/KG	UJ		UJ
CA2-SB4	5.7	6.2	SO	FR1	SW8021	SW5030	Benzene	=	1.3	1.2	UG/KG	J		J
CA2-SB4	5.7	6.2	SO	FR1	SW8021	SW5030	Chlorobenzene	ND	0	2.4	UG/KG	UJ		UJ
CA2-SB4	5.7	6.2	SO	FR1	SW8021	SW5030	Ethylbenzene	=	91.2	2.4	UG/KG	J		J
CA2-SB4	5.7	6.2	SO	FR1	SW8021	SW5030	m,p-Xylenes	=	122	2.4	UG/KG	J		J
CA2-SB4	5.7	6.2	SO	FR1	SW8021	SW5030	MTBE	ND	0	2.4	UG/KG	UJ		UJ
CA2-SB4	5.7	6.2	SO	FR1	SW8021	SW5030	o-Xylene	=	35.9	2.4	UG/KG	J		J
CA2-SB4	5.7	6.2	SO	FR1	SW8021	SW5030	Toluene	=	44.8	2.4	UG/KG	J		J
CA2-SB4	5.7	6.2	SO	N1	SW8021	SW5030	1,2-Dichlorobenzene	ND	0	4.7	UG/KG	UJ		UJ
CA2-SB4	5.7	6.2	SO	N1	SW8021	SW5030	1,3-Dichlorobenzene	ND	0	4.7	UG/KG	UJ		UJ
CA2-SB4	5.7	6.2	SO	N1	SW8021	SW5030	1,4-Dichlorobenzene	ND	0	3.5	UG/KG	UJ		UJ
CA2-SB4	5.7	6.2	SO	N1	SW8021	SW5030	Benzene	=	2.8	1.2	UG/KG	J		J
CA2-SB4	5.7	6.2	SO	N1	SW8021	SW5030	Chlorobenzene	ND	0	2.3	UG/KG	UJ		UJ
CA2-SB4	5.7	6.2	SO	N1	SW8021	SW5030	Ethylbenzene	=	96.6	2.3	UG/KG	J		J
CA2-SB4	5.7	6.2	SO	N1	SW8021	SW5030	m,p-Xylenes	=	132	2.3	UG/KG	J		J

TABLE A-2 (Continued)
QUALIFIED ANALYTICAL RESULTS

FACILITY 1748, SWMU 134

CAPE CANAVERAL AS, FLORIDA

LOCID	SBD	SED	MATRIX	SA CODE	ANM CODE	EXM CODE	ANALYTE	PARVQ	PARVAL	LABDL	UNITS	FINAL Q	MSRM	SURM
CA2-SB7	5.7	6.2	SO	N1	SW8021	SW5030	1,4-Dichlorobenzene	ND	0	3.6	UG/KG	UJ		UJ
CA2-SB7	5.7	6.2	SO	N1	SW8021	SW5030	Benzene	ND	0	1.2	UG/KG	UJ		UJ
CA2-SB7	5.7	6.2	SO	N1	SW8021	SW5030	Chlorobenzene	ND	0	2.4	UG/KG	UJ		UJ
CA2-SB7	5.7	6.2	SO	N1	SW8021	SW5030	Ethylbenzene	=	12.2	2.4	UG/KG	J		J
CA2-SB7	5.7	6.2	SO	N1	SW8021	SW5030	m,p-Xylenes	=	39.5	2.4	UG/KG	J		J
CA2-SB7	5.7	6.2	SO	N1	SW8021	SW5030	MTBE	ND	0	2.4	UG/KG	UJ		UJ
CA2-SB7	5.7	6.2	SO	N1	SW8021	SW5030	o-Xylene	=	26	2.4	UG/KG	J		J
CA2-SB7	5.7	6.2	SO	N1	SW8021	SW5030	Toluene	TR	2.3	2.4	UG/KG	J		J
CA2-SB8	5.7	6.2	SO	N1	FLAPRO	SW3550	TRPH	=	2173		UG/KG	J		J
CA2-MW1	0	0	WG	N1	FLAPRO	SW3510	TRPH	=	22100	210	UG/L	J		J

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APPENDIX E
GROUNDWATER CONTAMINANT LOSS RATE CALCULATIONS

Rev	By	Date	Ck	Date	Title	Author	Sheet	Of
					Time Required for Benzene, Ethylbenzene, and TRPH to Reach FDEP (1177), NFA Levels (GW), Facility 1743, Cal. Co. - 5	C. Snyder	2/2/99	1
							2	2

Assuming First Order Contaminant Depletion

$$C = C_0 e^{-kt} \quad \text{eq 3.2}$$

where: C = Contaminant Concentration at time t

C_0 = Contaminant Concentration at time "0"

e = Base of natural logs (approx. 2.71828)

k = First-Order Rate Constant (years^{-1})

Determining Time Required to Reach NFA Levels for a 2-Step Process for Each Analyte

- ① Determine k using 10/92 and 7/95 GW concentrations at MW-1 (Source Area)
- ② Determine t using k , 7/95 GW Concentration, and FDEP (1177) NFA Level

Given:	Analyte	Units	10/92 GW Conc.	7/95 GW Conc.	NFA Level
	Benzene	ug/L	73	7.3	1
	Ethylbenzene	ug/L	110	37.4	30
	TRPH	mg/L	40.5	20.1 J	5

$$t - t_0 = 7/95 - 10/92$$

$$t - t_0 = 5.75 \text{ yrs}$$

- ① Determine k for each analyte

Solving eq 3.2 for

$$\frac{C}{C_0} = e^{-kt}$$

Rev	By	Date	Ck	Date	Title	Author	Sheet	Of
			P.C.	2/2/99	Time Required for Benzene, Ethylbenzene, and TRPH to Reach FDEP (107) NFA Levels in Groundwater (GW) (Continued)	C. Snyder	2	2

Solving eq 3.3 for k (cont.)

$$\ln \left(\frac{C}{C_0} \right) = -kt$$

$$k = \frac{-\ln \left(\frac{C}{C_0} \right)}{t} \quad \text{eq 3.3}$$

Benzene $k = \frac{-\ln (7.3/73)}{5.75 \text{ yrs}} = 0.4004 \text{ yrs}^{-1}$

Ethylbenzene $k = \frac{-\ln (39.4/110)}{5.75 \text{ yrs}} = 0.1756 \text{ yrs}^{-1}$

TRPH $k = \frac{-\ln (22.1/40.5)}{5.75 \text{ yrs}} = 0.1053 \text{ yrs}^{-1}$

② Determine time required "t" to reach NFA levels

Rearranging eq 3.3 above to solve for t

$$t = \frac{-\ln (C/C_0)}{k} \quad \text{eq 3.4}$$

Now C_0 = GW Concentrations at 7/93 sampling event

C = NFA level

Benzene $t = \frac{-\ln (1/7.3)}{0.4004 \text{ yrs}^{-1}} = 4.96 \text{ yrs}$

Ethylbenzene $t = \frac{-\ln (30/39.4)}{0.1756 \text{ yrs}^{-1}} = 1.53 \text{ yrs}$

TRPH $t = \frac{-\ln (5/22.1)}{0.1053 \text{ yrs}^{-1}} = 14.1 \text{ yrs}$